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Elasticity of Food Consumption Associated with Changes in Income in Developing Countries

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PREFACE

Many developing nations have recently experienced severe shortages of food. They were ill-prepared to meet these food problems. India, Pakistan, and Turkey have had to increase food imports greatly in recent years. In other countries increased demand for food has forced up food prices and contributed to national inflation. In addition to rapid population growth, an important cause of the greater demand for food has been increased per capita income particularly in urban areas. Somewhat higher incomes have resulted in greater per capita food consumption due to the high marginal propensity to purchase more food in the developing countries.

Understanding the effect of increases in income on changes in food consumption has often been lacking. Where this effect has been understood, little research is available to provide quantitative estimates of changes in food consumption associated with changes in incomes. One reason firm income elasticity coefficients of food consumption are lacking is the difficulty of obtaining appropriate data. In some cases, the available data have not been obtained within a sufficiently rigorous theoretical framework to permit interpretation of the results. For this and other reasons, conflicting income elasticity estimates for food have often resulted.

This study was undertaken to learn if some general statements could be made about the income elasticity of food consumption during the economic development of a country. From such information, perspective could be gained as to the reasonableness of the scattered empirical estimates available. If more certainty could be assigned to the income elasticities of food consumption, nations would be better able to foresee their future food requirements. In this way plans for sufficient increases in agricultural production and food imports could be made.

In the course of this study, a number of models of the structural transformation of an economy and the associated changes in food consumption during the process of economic development were analyzed. In this way changes in food consumption were simulated to obtain likely magnitudes of the income elasticities of food consumption.

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	<u>Page</u>
Highlights.....	iii
Chapter I Introduction and objectives.....	1
Chapter II Measures of food.....	6
Chapter III The mathematical relations between the income elasticities of food at different levels of food measurement.....	10
Chapter IV The income elasticity of Total Food from Engel Curve analysis.....	14
Chapter V The increasing importance of Food at Retail as income rises.....	27
Chapter VI The income elasticity of Food at Retail during development.....	31
Chapter VII The influence of changes in the marketing margin on the elasticities of Food for Wholesale.....	38
Chapter VIII The income elasticity of Food for Wholesale during development.....	41
Chapter IX The income elasticity of Supplier Food during development.....	44
Chapter X Examples of rates of increase in food requirements during development.....	55
Chapter XI Conclusions and Policy Implications.....	60
Appendices	
1. A comparison of measures of food.....	72
2. Mathematical relations between income elasticities.....	74
3. International comparisons of Food Expenditure and Consumption Expenditure.....	80
4. The proportion of the active population engaged in agricultural occupations compared with per capita income in 70 countries.....	84

HIGHLIGHTS

During the process of economic development, major changes occur in the demand for food which affect the flow of food from farms into consumer's kitchens. If this flow is impeded, national growth may be greatly hampered. More knowledge is required about food requirements during periods of economic development to improve national economic planning.

In this exploratory study, the magnitude and changes in food flows were investigated as economic growth occurred. The purpose of the study was to work out the methodology for estimating these changes, and to evaluate its use in measuring these changes. All estimates of food in this investigation were made on the basis of the monetary value of food in constant dollars, not in terms of physical weight or quantity.

The manner in which national food consumption increases with economic development can be expressed by the equation $d = p + gn$, where (d) is the growth in food consumption, (p) rate of growth in population, (g) rate of growth in per capita income, and (n) the elasticity of demand for food associated with changes in income. This study is primarily concerned with estimating the income elasticity of food consumption during the process of economic growth since more uncertainty exists about its value than about population or income.

Estimates of income elasticities of food consumption depend upon the points in the production-marketing system at which the effect of changes in food consumption associated with changes in income are measured. Chapter 2 carefully reviews alternative measures of food at different points in the production-marketing system. Six measures of food used were chosen for analysis since these measures cover the various levels of consumption and flow of food from the farm to the consumer. They also include home-produced and home-consumed food and marketing cost.

An Engel Curve for food was derived from consumption data for many countries. The results of this analysis provide evidence that the income elasticity of total food consumption per capita must range between .9 and .4 over the long term. The usual range for this elasticity appears to be between .6 and .8.

The econometric relations between the income elasticities of food at different levels of food measurement were also explored, assuming no changes in relative prices. The equations obtained show that the income elasticities of food under certain circumstances are the same at different levels of food measurement. However, due to structural changes in national economies during economic growth, it appears more likely that different income elasticities will persist at different levels of food measurement over long periods of time. For example, the difference between the elasticities of total food consumption and food at the retail level may be as great as .6.

The shift of population from rural to urban areas is a major structural change which influences food elasticities in economies undergoing economic development. Three alternative food flows--low, medium, and high--are considered in this study to estimate the proportion of food marketed at the

wholesale and retail level at different stages of economic development. The medium food path was estimated by data from 70 countries on the proportion of the nonagricultural labor force to the total labor force. On this food path, at the \$50 per capita income level, about 25 percent of the total food consumption passes through wholesale and retail marketing channels; about 85 percent of total food passes through these channels at the \$1,000 per capita income level. High and low food paths were also used to provide a wider range in the order of magnitude of the proportion of total food that might be expected to pass through the marketing channels during economic development in the various countries.

Due to the shift of food into the retail food channel during the process of economic development, the income elasticities of food at the retail level were found to be some .2 to .6 higher than the income elasticity of total food consumption. The most likely range for the long-run income elasticity of food at the retail level appears to be from .8 to 1.2. This range of elasticities is much higher than those seen in many studies and suggests a more rapid rate of growth in demand for retail food during development than is generally indicated.

The income elasticity of food at the farm gate was generally found to be at least .6 or higher. However, changes in the marketing margin can have considerable influence on the income elasticity of food at the farm gate. The effect of the marketing margin was found to be as great as .5. In general, a decreasing marketing margin increases the food elasticity at the farm gate and vice versa.

Estimates of the resources needed for agricultural production can be better gauged if the domestic food production requirements are known. For this purpose, the income elasticity of net farm food production was estimated. These results indicate that generally the elasticity of food at this level was about .1 to .2 less than the income elasticity of total food consumption, thereby, placing the range of most likely elasticities for net total food consumption at the farm level in the range from .4 to .6. The higher figure is more likely at low per capita income levels.

Important implications of high income elasticities on the rate of growth in national food requirements emerge from a dramatic rise in the rate of growth of food consumption as development gets underway. For example, the transition of an economy from a stagnant state, where population and income remain constant to an economy with high levels of per capita income, is likely to increase the rate of growth in food requirements at the farm gate by as much as 5 percent per year in the early stages of economic development before it finally decreases to about 3 percent.

Governments planning economic development should be aware that rapid increases in food flows through marketing channels are likely to cause inflationary pressures on food prices unless marketing channels are made capable of handling these increased flows. An alternative policy for reducing the pressure on marketing services would be one to slow the movement of population into urban areas. If this were achieved, less food would need to be transported into urban areas.

ELASTICITY OF FOOD CONSUMPTION ASSOCIATED
WITH CHANGES IN INCOME IN DEVELOPING COUNTRIES

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Chapter I. -- INTRODUCTION AND OBJECTIVES

Rapid economic growth in the developing nations is a universally recognized need. The United Nations' proclamation of the Decade of Development attests to the worldwide nature of this objective. To achieve rapid economic development most nations have found planning essential. Since food makes up a large share of consumption in most developing countries, planning for food must be given major attention. One of the major factors in estimating food requirements during economic development is the increase in food consumption associated with higher income. This response of consumers to changes in income is called the income elasticity of food consumption. The nature of the income elasticity of food consumption in developing countries is imperfectly understood, due to lack of available data and to insufficiently elaborated economic theory. This study was undertaken to provide improved knowledge of the income elasticity relation during the process of economic growth through use of existing economic theory and available empirical data.

Nations had little concern with the pace of economic growth, the level of personal income, or the level of per capita food consumption under the laissez faire economic philosophy. Governments felt that their primary development task was to facilitate the activities of entrepreneurs. Governments not satisfied with their economic performance found little economic knowledge available to aid in achieving their objectives.

In the 20th century, particularly since World War II, national attitudes toward economic problems have changes radically. A new spirit has come to pervade most nations. Governments are now held responsible for a reasonable pace of economic growth. The United Nations has proclaimed economic development to be a world goal during the decade of the sixties.

The United States has shown by the magnitude of its international aid programs how important economic growth is for the Free World. The Marshall Plan helped European nations to recover rapidly from the Second World War and to become strong partners in the western world. U.S. aid has now shifted its emphasis to the developing nations. Here the objective is the much more difficult task of helping relatively poor societies get the economic development process started. The goal of economic assistance is a group of strong and independent partners in a Free World. The task of achieving economic growth in developing countries is even more difficult than in the past. For today,

rates of population growth in many of these countries are higher than they have ever been, in some cases rising above 3 percent annually.

The peoples of these developing lands are observing the economic prosperity of other nations. Consequently, they, too, greatly desire a better economic life for themselves. Food shortages are increasingly difficult for such people to tolerate. Governments which do not succeed in solving the pressing economic problems in these lands may be replaced--possibly by Communism. Economic growth in developing countries is, therefore, crucial for the economic growth and political security of the United States and the Free World. Rapid economic growth is one of the major goals of mankind in the second half of the 20th century.

The new world focus on rapid economic growth has been made possible by greatly increased knowledge of how to achieve economic development. Better tools are now available to aid in controlling the economic and social development of nations. One of the principle tools presently used by a great many nations is an economic development plan. Economic planning has been made an integral part of the Alliance for Progress, for example. Economic plans aid governments in deciding how to make optimum allocation of the limited resources available for national development. Many nations have set up national planning organizations and some countries have already carried out a number of development plans.

In most developing countries the agricultural sector is by far the largest sector. Food makes up a high proportion of production, accounting for an average of 76 percent of agricultural production in 21 Latin American countries. 1/ Thus, if a firm estimate of the probable rate and nature of increase in food consumption can be obtained, development goals for the agricultural sector can be specified much more precisely.

In spite of the dominance of the agricultural sector, enthusiasm for rapid industrial development has led many countries to devote a very large proportion of their development resources to the industrial sector. The resulting neglect of the agricultural sector led in many cases to food problems. Recent large increases in concessional sales of food to some developing nations has highlighted impending food shortages. As the seriousness of agricultural shortfalls have become more apparent, development plans have been modified so as to direct more resources to the agricultural sector. However, much uncertainty remains about how fast food supplies need to be expanded to meet national requirements, and how much emphasis needs to be placed on the expansion of marketing and distribution facilities.

Economists are in general agreement that rapid inflationary price spirals must be avoided in order to achieve rapid, sustained economic growth (Johnstor and Mellor 32, p. 572-74). Food prices have a significant effect on the overall price level in low-income nations as one-third or more of Private Consumption Expenditure is allocated for food. Therefore, to prevent inflation food supplies must expand rapidly during development either from increased production or from imports to meet the increased demand for food.

1/ This statement is based on 1961-62 data (54). (Underscored numbers in parentheses refer to Literature Cited p. 67).

There are few firm guidelines available for use in estimating how rapidly the consumption of food and other agricultural products will increase. Thus, it is not certain what rates of growth in food supplies are required during different stages of economic development. Much better methods for obtaining estimates of food needs are required in order to answer such questions as: how much does the value of food consumption increase in low-income countries when incomes begin to rise? How does industrialization and urbanization influence food requirements at the farm gate and at the retail level? How does the demand for marketing services change and affect food consumption during development? What rates of increase in commercial and in home-produced food supplies are required during economic development to meet food consumption requirements?

Answers to questions like these are needed by the United States and other developed countries to better gauge the future export demand for food and plan aid programs aimed at helping to meet the emerging food needs in low-income nations. The less-developed countries obviously require answers to these kind of questions in order to make their own development plans more realistic.

A major reason for the uncertainty about national food requirements is due to imperfect knowledge and understanding of the way consumers respond to increased income in terms of food purchases. This response of consumers to increased income is measured by the income elasticity of food. Technically, the income elasticity of food indicates the percentage increase in purchases of food which result from a specified increase in per capita income. Thus, for example, if the income elasticity of food is .7, this figure indicates that for a 10-percent increase in income, purchases of food per capita increase 7 percent. In order to achieve rapid economic growth sufficient food must be available. With the use of the income elasticity concept for food, better knowledge of future food requirements may be acquired. Professional recognition of the importance of the income elasticity relation for food during the development process is illustrated by considerable research especially that of Goreux (7), Burk (5), Cochrane, Mackie and Chappell (14).

Lack of reliable data for the income elasticities of food consumption make realistic estimates of national food needs exceedingly difficult for planners. That little empirical income elasticity data is available for the developing nations is often conflicting. Consumption theory relating to the income elasticities of food during economic development has not been sufficiently developed to be of much assistance. It is for these reasons that the present study was undertaken. The objective was to see if available data and theory could be further analyzed in order to provide considerably improved knowledge of the income elasticity of food consumption during economic development.

The basic tools employed in this study are the income elasticity concept and mathematical relations between the income elasticities of food at the different levels of measurement. Data for estimating rates of growth in food requirements were obtained by considering the income elasticities of food consumption at five levels or points of food measurement starting with net farm food production and proceeding to food consumption in the home.

In the course of the study, the shortcomings of present methods of estimating food needs and other aspects of the problem are taken up. These

discussions include a review of methods of measuring food consumption and consideration of changes in the importance of home-produced food during the process of development. The effect of changes in the marketing margin on the flow of food is also studied. The major objective of the analysis is to develop a way of obtaining reliable methods for estimating the rates of growth in food consumption at specified points or levels. The study also outlines range of income elasticities for food which appear to apply to many of the newly developing countries.

Importance of Reliable Income Elasticity Estimates for Planning

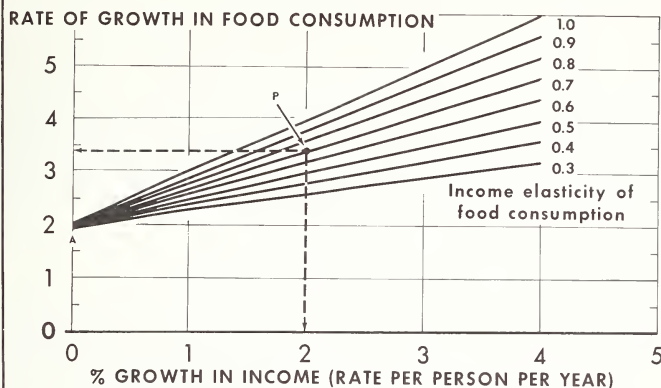
Consideration of the way in which two major variables, population and income, determine the value of food consumed points out the importance of obtaining reliable estimates of the inelasticity of food consumption. The mathematical relation between these variables and food consumption was given by Ohkawa (40, p. 49). This relation indicates that the rate of increase in national food consumption is equal to the rate of population growth plus the product of the rate of growth in per capita income and the income elasticity of food ($d = p + gn$). ^{2/} This equation assumes no change in relative prices. Although other variables have some influence on food consumption, economists recognize these three variables as the most important (Johnston and Mellor 3 p. 572; Heady 30, p. 645).

Ohkawa's equation shows that if little increase in per capita income occurs, population growth will account for most of the increase in food consumption. However, the equation also shows that if considerable increases in per capita income occur, estimates of food consumption require knowledge of the income elasticity of food. In fact, the greater the growth in income relative to population growth, the greater will be the influence of the income elasticity of food on the amount of food demanded. Most newly developing countries plan to increase income rapidly. If they succeed, the income elasticities of food will have a major influence on the demand for food.

The importance of using correct elasticity coefficients for food is easily seen from a numerical example (fig. 1). At point "A" a 2-percent rate of increase in population has been assumed. If there is no increase in per capita income, the rate of growth in demand for food is the same as the population growth rate, 2 percent. However, should an economy be developing rapidly and achieve, say, a 2-percent rate of increase in per capita income, the rate of growth in demand for food would be considerably greater. The amount by which it will be greater depends jointly on the income elasticity of demand for food and the rate of increase in per capita income. If the income elasticity of food were .7, it is seen from point "P" that the overall national rate of growth in food consumption would be 3.4 percent; 2 percent due to the increase in population and 1.4 percent due to the joint effect of the increase in per capita income and the income elasticity of food.

^{2/} Ohkawa's complete formulation of this equation is: $d = p + gn + pgn$. He dropped the last term reasoning that it is of small importance. Over a 1 year span with typical values for p, g, and n, the last term has a value of less than 1 percent of the sum of the other two terms (40, p. 49).

FOOD CONSUMPTION GROWTH RATE RELATED TO INCOME GROWTH AND FOOD INCOME ELASTICITY*



* ASSUMING A 2 PERCENT RATE IN POPULATION GROWTH.

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Figure 1

Of the three parameters in Ohkawa's equation, estimates of the income elasticity of food are the least satisfactory. Much is known about probable future rates of population growth. This information is available from many studies conducted by the Population Branch of the United Nations Department of Economic and Social Affairs, by the Office of Population Research at Princeton University, and by other national and international organizations (13, 53). Reliable estimates of rates of growth in per capita income are becoming available from governments and international agencies with improvements in estimates of Net National Product.

An example of the need for much more knowledge of elasticities of food consumption is seen from data for India and Japan. In a recent study of India, Cole and Hoover (13, p. 125-26) estimated that the income elasticity of food was .8 for the decade of the 1960's without specifying the level of measurement. In contrast to this elasticity estimate, a recent study in Japan found an income elasticity of food at the farm gate to be .23 for the period from 1922 to 1937 (Noda, 39, p. 122). Elasticity estimates as far apart as these cause great differences in the estimates of food consumption requirements. The magnitude of the difference in this example is illustrated with Ohkawa's equation. If per capita income increases 2 percent per year, an income elasticity for food of .3 instead of .8 results in a 1 percent lower estimate of the rate of growth in national food needs. If the population grows at a rate of 2 percent, the lower elasticity (.3) provides an estimate of food needs which is more than one third lower than is obtained with the use of the higher (.8)

elasticity. A possible error of one-third may thus be caused by poor estimates of income elasticities for food.

Importance and Objectives

In summary, this study investigates an important aspect of the economic growth process. Income elasticities for food consumption at five levels of food measurement are discussed in this study. The focus is on the likely magnitudes of these elasticities at the different levels of food measurement during the process of economic development. With such knowledge, governments may obtain much better estimates of the rates of growth in food requirements during periods of economic growth. In the following chapter we turn first to a careful definition of the food measures which will be used in the study.

Chapter II. -- MEASURES OF FOOD

Food flows into consumers' kitchens either directly from the farm, as the case of home-produced food, or through marketing channels--restaurants, markets, stores. During the marketing process many services are added to food so that in the end it has a higher unit value and often less physical weight. It is clear for example, that the value and weight of food at the retail store will be different from the value and weight of the same food when it leaves the farm. Thus, very specific definitions of the points of measurement and the methods of measuring food are required in order to be certain of the relation between the value of food consumption and changes in income. This is particularly important as these relations are found to be different at different levels or points of food measurement.

The importance of careful specification of the food measures used was demonstrated by Daly (18), Goreux (27, p. 6), and Burk (5, 7). Their work has shown that different income elasticities occur when food is measured at various levels or in different ways over the same time period. In another example, Bunkers and Cochrane (4) demonstrated clearly that the income elasticity of food measured at the retail level was quite different from the income elasticity of food measured at the farm gate.^{3/} Additional data on this point gathered over long periods of time for the United States and Sweden give further evidence on the different elasticities obtained at different levels of food measurement (Kuznets 36, p. 47). The next chapter in this report will show how different elasticities relate to each other mathematically in the process of development.

Food is generally measured in two ways, by its monetary value and by some physical measure such as its weight or volume. The monetary value (V) of a basket of food can be considered to be the sum of the prices (p_i) times the quantities (Q_i) of all the food in the basket. In symbols then $V = \sum p_i Q_i$. In this study, in agreement with consumption economics theory, the value of food (V), is used as the food measure. There is little question that consumers to

^{3/} The analysis of U.S. food data in this article is similar to parts of this study. Bunkers and Cochrane, however, limited their consideration to farm foods by excluding fish and imports.

to maximize the value of food purchases in terms of satisfactions obtained from a limited budget. In the long run, consumers are not greatly concerned with the weight or volume of food consumed. The most one can say about the relation between income and food as measured by weight or volume is that food weight and volume appear to remain about the same; perhaps there is some gradual decline. Thus, the sum of the weight or volume of the "Q's" will remain about the same or decline gradually during development.

However, as Engel stated more than a century ago, there are consistent relations between increases in per capita income and the value of food purchased and consumed. The value measure for food, (V) is therefore used throughout this study. It should be noted, in passing, that the major way in which the value of food consumed increases during development is through changes in the number of the different "Q's" and by the substitution of higher unit value "Q's" for lower valued ones. Unit prices (P_i) need not change at all for the value of food consumption to increase.

In analyzing changes in food consumption, particularly in the newly developing countries, there is the additional difficult problem of lack of food quality data. This difficulty of obtaining empirical estimates of the value of food was kept in mind during the study, particularly while choosing the measures to be used.

The measures of food chosen for use in this study were developed from measures currently in use by the U.S. Department of Agriculture (Burk, 7). ^{4/} They include:

1. Supplier value of food used by civilians (TFV-5) is the sum of: ^{5/}
 - a. Farm value of domestic food sold (TFV-1)
 - b. Farm value of Home-produced Food (TFV-2)
 - c. Import value of imported foods (TFV-3)
 - d. Wharf value of domestic farm foods sold (TFV-4)
2. Retail value of foods used by civilians (TFV-9) is the sum of:
 - a. Retail value of domestic farm foods sold (TFV-6)
 - b. Retail value of Home-produced Food (TFV-7)
 - c. Retail value of imported and nonfarm food (TFV-8)
3. Market value of all civilian food (TFV-10a excludes taxes and tips, TFV-10b includes taxes and tips), is constructed as follows:
 - a. Retail value of all foods sold (TFV-6 + TFV-8)
 - b. Farm value of all Home-produced Food (TFV-2)

plus

^{4/} Burk (p. 3) defines food as "...those (commodities) customarily consumed as human food...encompassing fishery products and spices as well as farm products." Alcoholic beverages are not generally included.

^{5/} The symbols TFV-5 etc. refer to Burk's specific measures of Total Food Value (7, p. 39-42).

- plus c. Eating place markup over retail for food sold through eating places
 - minus d. Marketing charges saved on food sold prior to retail level
4. Expenditures for all foods by civilians including taxes and tips (TFV-10)
- a. Market value of all civilian food including taxes and tips (TFV-10)
- minus b. Farm value of all Home-produced Food (TFV-2)

Of the four major measures defined above, "Supplier value of food used by civilians" (TFV-5) which will be labeled Supplier Food was found suitable for this study. The full set of six food measures chosen for this investigation are defined below. They were developed by arranging in a somewhat different way some of the sub-measures listed above.

1. Supplier Food. (V_0) The sum of "Home produced Food" and "Food for Wholesale" (TFV-5).
2. Home-produced Food. (V_S) The farm value of Home-produced Food which is consumed at home (TFV-2).
3. Food for Wholesale. (V_P) The sum of the farm value of domestic farm food sold for domestic consumption (TFV-1), the import value of imported foods (TFV-3), and the wharf value of the domestic fish catch (TFV-4).
4. Food at Retail. (V_R) The retail value of all food sold (TFV-6 + TFV-8).
5. Marketing Costs. (V_M) Defined as "Food at Retail" minus "Food for Wholesale."
6. Total Food. (V_A) The sum of "Home-produced Food" and "Food at Retail."

The relation between these six measures is shown graphically in figure 2 and in Appendix 1.

The use of these food measures is justified because (1) they cover the whole range of the flow of food from the point of production to final consumption, (2) they are appropriate for low income countries where Home-produced Food is an important proportion of Total Food, and (3) these measures are simple enough to allow an analysis with existing resources and empirical data.

The use of farm prices instead of retail prices in estimating the value of Home-produced Food is defended on the basis that it is economically more realistic. Farmers' choices as to whether to retain food for home consumption or sell it are based on the price they would receive. An additional reason for using the farm value instead of the retail value of Home-produced Food (TFV-7) is that use of the latter would result in underestimating the influence of changes in the ratio of Home-produced Food to Total Food as development occurs. This will be shown in a later section.

Food at Retail is defined here as the retail value of domestic farm food sold plus the retail value of imported and nonfarm food. This definition differs from the measure "Retail value of foods used by civilians" (TFV-9) by

FOOD MEASURES IN THE MARKETING CHANNEL

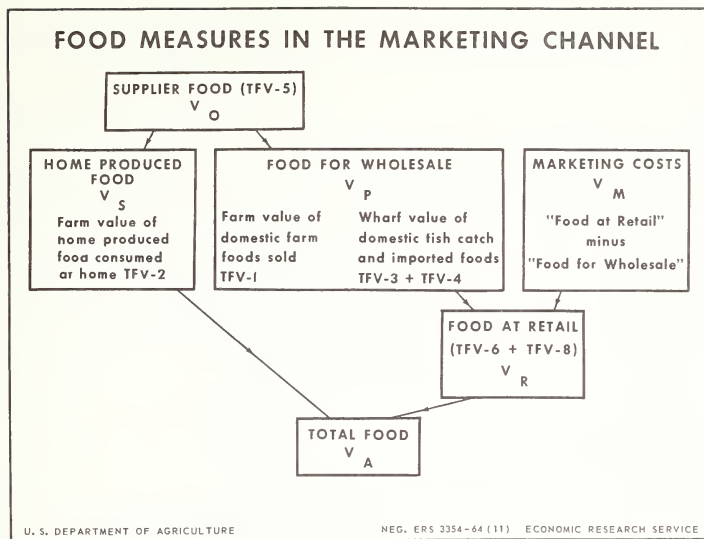


Figure 2

cluding the retail value of Home-produced Food (TFV-7) (Appendix 1). The concepts used in this study require an estimate of the value at the retail level of food passing through marketing channels. The TFV-9 measure estimates the retail value of Total Food including Home-produced Food.

A Marketing Costs measure was required by this study because, as will be seen later, the way the marketing margin behaves, greatly influences the income elasticity of Food for Wholesale. Marketing Costs are defined here as the difference between Food at Retail and Food for Wholesale. The marketing margin is Marketing Costs divided by Food at Retail.

Total Food provides an estimate of the value of the food consumed by a nation at market prices. It is the sum of Home-produced Food at wholesale prices and Food at Retail. This Total Food measure is different from the "Market value of all civilian food" (TFV-10) since Total Food does not include an estimate of the eating place markup above retail value nor does it include marketing charges on food sold prior to the retail level (Appendix 1). These adjustments were excluded because in low-income nations with sparse food data, good estimates of eating place markups and marketing charges saved are almost impossible to obtain.

The use of the Total Food measure as defined here instead of the Market Value of All Food (TFV-10) results in important differences in the estimate of food consumption only in countries where eating place markups and marketing charges saved are relatively important. A comparison of the Market Value of All Food and Total Food shows that in the United States the two series

diverge (table 1). This is due to the fact that the eating place markup over retail has increased considerably in the United States in recent years. However, the two food estimates are quite close in the 1930's. The average data for 1939 show that Total Food was 97.2 percent of the Market Value of All Food. Thus, Total Food appears to be a good substitute for the more complex Market Value of All Food at lower levels of per capita income where the eating place markup over retail is relatively unimportant.

Table 1.--A comparison of the value of "Total Food" consumption per capita by civilians in the United States, deflated by the Consumer Price Index to 1947-49 dollars

11-year over- : Market Value of All : Total Food (Home- : Ratio of Total Food				
lapping aver- : Food, including taxes: produced Food plus : to Market Value				
ages centered : and tips (PFV-10b) <u>1</u> /: Food at Retail) <u>2</u> : of All Food				
		Dollars	Dollars	Percent
1934.....:		222	221	99.5
1939.....:		249	242	97.2
1944.....:		302	284	94.0
1949.....:		336	311	92.6
1954.....:		331	305	92.1

1/ PFV-10b is TFV-10b divided by the population to obtain per capita instead of total estimates of food consumption. Burk (7, p. 39-42).

2/ The definition of Total Food used in this study.

Chapter III. -- THE MATHEMATICAL RELATIONSHIPS BETWEEN THE INCOME ELASTICITIES OF FOOD AT DIFFERENT LEVELS OF FOOD MEASUREMENT

In this chapter the mathematical relationships between the income elasticities of the value of food consumption at the different levels of food measurement are sketched out for use in succeeding chapters. Associated methodological questions are also considered. Readers not primarily interested in these technical aspects of food elasticities may skip to the next chapter. A mathematical appendix is attached for others concerned with details of the derivation of these equations.

The large number and very long history of empirical studies of the income elasticity of food consumption have shown that other variables besides income influence food consumption. These variables include: Size of family, changes in taste, relative price changes, urban or nonurban environment, lags in adjustment to new income levels, and others. The number of variables included in a model influences the estimates of income elasticity. A recent review of new developments in food consumption analysis by King (35) and additional comments by Sparks (47) demonstrate that at the present time there is little general consensus about the most appropriate methods for analyzing income-food relationships. Some of the statistical quandaries of food consumption analysis were also reviewed recently by Rojko (45). With this methodological situation in view, it was decided to limit the present study to consideration of the effect of income alone on food consumption. Other variables influencing

the income-food relationship are therefore assumed to be relatively unimportant for this study. Over long periods of economic development, there is little doubt that income is the major variable influencing food consumption.

A major complexity in studying the income elasticity of the value of food consumption arises from the different levels at which food may be measured. In consumption theory, the income elasticity of the value of food consumption refers to the response of consumers to changes in income in terms of food purchased at retail and consumption of Home-produced Food. Food at Retail plus Home-produced Food was labeled Total Food in the preceding chapter. In some studies, however, the focus has been on changes in consumers' purchases of food at Retail as their income rises. Other studies have examined instead the income elasticity of Food for Wholesale. Consideration of the relationships between different measures of food shows that elasticities based on food measured at some distance in the marketing channel from the consumer will be affected by structural changes in the economy. An example of this kind of structural change is a change in the marketing margin. The income elasticity of Food for Wholesale reflects consumers' responses to changes in income in terms of budget allocations, and changes in the structure of the economy, including those in the marketing margin.

Perhaps an elasticity of this sort which includes structural changes should be given another name such as a "development elasticity of Food for Wholesale." A term such as this is conceptually similar to the "total elasticity" term proposed by Buse (10). This study will, however, continue to use the more common term, the income elasticity of the value of food consumption, but always with reference to a certain level of measurement.

Due to the exploratory nature of this study and the very limited kinds of data usually available in newly developing countries, this study is limited to analysis of the gross relations between income and food consumption at four levels in the marketing process. There include: Total Food, Food at Retail, Food for Wholesale, and Supplier Food levels.

In the preceding chapter, these and other measures of food were defined carefully. Care is also needed in defining "income." The specification of income is particularly difficult in newly developing nations due to the difficulty of obtaining firm data. Theoretically, Disposable Income is the measure of income desired for analysis of the income-food relation. Unfortunately, for many of the nations for which income elasticity estimates are needed, data on Disposable Income are not available. Thus, Gross National Product, or preferably Net National Product, has to be used as a surrogate for Disposable income.

If Disposable Income remains a constant percentage of GNP or NNP, the use of these surrogates does not influence estimates of income elasticity. 6/

6/ This can be shown in the following way: Let I = Disposable Income and kI = GNP. Since $\frac{I}{I} = \frac{kI}{kI}$, the income part of the elasticity formula, $\epsilon = \frac{F}{I} \cdot \frac{I}{F}$, is not influenced if a surrogate for Disposable Income such as $\frac{F}{kI} \cdot \frac{kI}{F}$ is used, providing the surrogate remains a constant percentage ratio to Disposable Income.

During years when there are few major changes in a country's economy, the use of the surrogates is likely to be valid. In some parts of this study, Gross National Product is used as a surrogate for Disposable Income. Its use is unlikely to influence the conclusions of the study in a major way.

A related question concerns the use of Private Consumption Expenditures or total family expenditures, neither of which includes savings, instead of Disposable Income. In this study, some of the elasticities were calculated with respect to total expenditures and some with respect to income. Since savings are not likely to change greatly as a proportion of income the elasticities with respect to total expenditures and with respect to income will be essentially the same (see footnote 6, p. 11). Thus, throughout the study expenditure elasticities are assumed to have the same value as income elasticities, and the terms are used interchangeably.

An additional methodological matter is the question of price changes. This report was developed on the assumption that relative prices for all goods remain approximately the same during a country's development. This assumption limits the applicability of the results obtained, particularly if food prices change relative to other prices. It should be remembered that the restriction that relative prices remain the same does not necessarily preclude the handling of data from nations undergoing inflation. For inflation in the value of money may not cause major changes in relative prices, although it often does. However, throughout this study the analysis and data are presented in constant dollars for clarity of presentation and understanding.

A further development of the approach used in this study could incorporate relative price changes in order to arrive at elasticity estimates with varying prices. A study by Frisch (24) suggests a direction of future research.

The definition of the term elasticity raises some additional methodological questions. Elasticities may be approached as point elasticities or arc elasticities. The latter refer to the average elasticity between two points on a mathematical function while the former estimates the elasticity at a specified point on a mathematical function. As there is little agreement on the mathematical functions which relate income and food consumption, the present study uses arc elasticities for specified changes in income. This choice makes it possible to avoid choosing between specific mathematical functions.

In certain sections of the report the double logarithmic function, $\log F = a + b \log I$, was used for estimating the income elasticity of food. This function was chosen because it is commonly used in elasticity work and has a constant elasticity. It is therefore similar to the use of arc elasticities. Further discussion of the equation and its relation to arc elasticities is given in Appendix 2.

Having discussed a number of preliminary matters, we will now turn to the question of the mathematical relations between income elasticities of food consumption at different levels of measurement. The first relation taken up is the one between the income elasticity of Food at Retail and the income elasticity of Total Food. This is the relation upon which Chapter 6 is based.

a basic equation is: $e_R = e_A + e_{W_R}$ (Equation A1 in Appendix 2). This is, the income elasticity of Food at Retail is equal to the income elasticity of Total Food plus the elasticity of the proportion W_R . The proportion, W_R , is simply the ratio, Food at Retail divided by Total Food. Thus, the relation between the income elasticity of Food at Retail and the income elasticity of Total Food depends upon the way the ratio W_R changes relative to changes in income. (Proof of this is given in Appendix 2).

A similar mathematical relation is used in chapter 7, where the relation between the income elasticity of Food for Wholesale and the income elasticity of Food at Retail is examined. The equation is: $e_P = e_R + e_{U_P}$ (Equation A5, Appendix 2). Thus, the income elasticity of Food for Wholesale is equal to the income elasticity of Food at Retail plus the elasticity of the proportion U_P . U_P is the ratio, Food for Wholesale divided by Food at Retail. Therefore, the way that the proportion U_P changes relative to changes in income will determine the relation between the two food elasticities.

By combining the two preceding equations in chapter 8, the relation between the income elasticities of Food at Retail and the income elasticity of Total Food was obtained. The relation is: $e_P = e_A + e_{W_R} + e_{U_P}$ (Equation A6, Appendix 2). This equation shows that the income elasticity of Food for Wholesale is equal to the income elasticity of Total Food plus the sum of the elasticity of the proportion W_R and the elasticity of the proportion U_P . With this relation, it was possible to investigate the elasticity of Food for Wholesale given the elasticity of Total Food and the changes in W_R and U_P .

The final step in this study was to investigate the relation between the income elasticity of Supplier Food and the income elasticity of Total Food. This is undertaken in chapter 9. An equation which specifies the relations between these two income elasticities is: $e_O = e_A + e_{W_R} + e_{U_P} - e_{T_P}$ (Equation A13, Appendix 2). This equation can be interpreted as, the income elasticity of Supplier Food is equal to the income elasticity of Total Food plus the elasticities of the proportions W_R and U_P minus the elasticity of the proportion T_P . T_P is the ratio, Food for Wholesale divided by Supplier Food. With the equation it was possible to investigate the elasticity of Supplier Food when various values were specified for the other variables.

To summarize, equations have been given which specify the relations between the income elasticities of food for the following four sets of food measures: between Total Food and Food at Retail, between Food at Retail and Food for Wholesale, between Total Food and Food for Wholesale, and between Total Food and Supplier Food. Additional equations--although not used in this study--are given in Appendix 2. The four equations given above provide a framework for investigating how the income elasticities of food at the different levels of food measurement change during the process of economic growth.

Chapter IV. -- THE INCOME ELASTICITY OF TOTAL FOOD FROM ENGEL CURVE ANALYSIS

This is the first of three chapters developed to obtain estimates of the income elasticity of Food at Retail during economic development. The first equation in the preceding chapter specifies that to obtain the income elasticity of Food at Retail, data are needed for three other variables: The income elasticity of Total Food, changes in the ratio of Food at Retail to Total Food, and changes in per capita income. The present chapter will consider appropriate values for the income elasticity of Total Food during development. The following chapter will investigate changes during development in the ratio of Food at Retail to Total Food. In the sixth chapter these data are combined to estimate the elasticity of Food at Retail during development.

This study commences with a consideration of the income elasticity of Total Food because it is assumed that this elasticity is fundamental in influencing the other food elasticities which are further removed from the consumer. The data on the income elasticity of Total Food are sparse and confusing. There are three ways in which Total Food income elasticity data are obtained: (1) From the analysis of time series data, (2) from cross-section budget study analysis, and (3) from international comparisons of food consumption data. Somewhat different results have been obtained from the three types of analysis; consequently there is little general agreement about appropriate income elasticities for Total Food particularly in newly developing countries.

Time Series and Budget Study Analysis

The first two kinds of analysis, time series and cross-section budget study, will be considered first. From the point of view of economic development, time series data running over a number of decades are the most desirable for estimating the income elasticity of Total Food during economic growth. Detailed knowledge of the elasticities experienced by many nations during their growth would provide great insight into expected food demand in developing nations as economic development continues. Unfortunately, there are relatively few time series available, and the evidence they provide is somewhat conflicting.

The representative time series elasticities given in table 2 were selected as being as nearly comparable as possible. They were all calculated with the double logarithmic equation. ^{7/} For the United States the time series estimates of the income elasticity of food vary from a high of .90 down to .24. The elasticities over the longer span appear to be higher, with some indication that during recent periods the elasticity in the United States has become less, particularly when adjustment is made for changes in the relative price

^{7/} Additional references to major single equation time series work include Burk's studies given in the reference list, Wold and Jureen (56), Daly (18), and Bunkers and Cochrane (4). Major works, which use sets of simultaneous equations, the results of which are not directly comparable with single equation analysis, include: Gershick and Havalmo (25), Tobin (50), and Stone (49). Two somewhat different approaches were used by Clark (12) and Jureen (34).

Table 2.--Representative estimates of the income elasticity of total food, by country and time period, using logarithmic equations based on different data and methods of measuring food

Country:	Kind of data :	Kind of measure		Income :			
	and :	Food :	Income :	elas- :	Comments :	Source :	
	time period :			ticity 1/ :			
	<u>Time-series</u> :						
United States :	1869-1933 :	Food share of consumption expenditures :	Consumption : expenditure :	.74 :	Not adjusted for relative changes in food prices :	1/ :	
	1909-1955 :	do. :	do. :	.90 :	do. :	do. :	
	1929-1941 :	Market value of all food (PFV-10a) :	Disposable money income per capita :	.68 :	do. :	2/ :	
	1948-1957 :	do. :	do. :	.38 :	do. :	do. :	
	1929-1941 + :	do. :	do. :	.87 :	do. :	do. :	
	1948-1957 :	Composite "quantity" index of all food (PFQ-8) :	Real disposable income per capita :	.33 :	X ₃ Coef. = -.42 3/ :	do. :	
	1948-1957 :	do. :	do. :	.24 :	X ₃ Coef. = -.14 3/ :	do. :	
	1929-1941 + :	do. :	do. :	.43 :	X ₃ Coef. = -.02 3/ :	do. :	
	1948-1957 :						
	<u>Budget studies</u> :						
	Spring 1942 :	Total market value of food at home and away :	Disposable money income per capita :	.30 :		4/ :	
	Spring 1955 :	do. :	do. :	.25 :		do. :	
	Spring 1955 :	Consumption of food :	do. :	.12 :	Index of "quantity" of food measured with retail prices :	do. :	
	Spring 1955 :	Total food expenditure :	Disposable income per household :	.41 :	Both expenditure and income include home-produced food :	5/ :	

See footnotes at end of table.

Table 2.--Representative estimates of the income elasticity of total food, by country and time period, using logarithmic equations based on different data and methods of measuring food -Continued

Country	Kind of data and time period	Kind of measure		Income elasticity	Comments	Source
		Food	Income			
Japan	<u>Budget studies:</u>					
	1951-1952	Total food expenditure	Total household income	.65	Home-produced food included in expenditure and income	5/
Japan	1955-1956	do.	do.	.58	do.	do.
Sweden	<u>Time-series</u>					
	1864-1948	Food share of consumption expenditures	Consumption expenditures	.71	Not adjusted for relative changes in the price of food	1/
	<u>Budget studies:</u>					
	1948	Total food expenditure	Total household income	.53	Home-produced food included in expenditure and income	6/
	1952	do.	do.	.62	do.	do.
United Kingdom	<u>Time series</u>					
	1880-1954	Food share of consumption expenditures	Consumption expenditures	.61	Not adjusted for relative changes in the price of food	1/
Germany	1851-1913	do.	do.	.77	do.	do.
Italy	1861-1955	do.	do.	.96	do.	do.
Norway	1865-1950	do.	do.	.52	do.	do.
Canada	1870-1955	do.	do.	.73	do.	do.
Egypt	<u>Budget studies:</u>					
	1955	Total food expenditure	Total household income	.92	Home-produced food included in food and income	5/
Ghana	1954-1955	do.	do.	.81	do.	do.
Greece	1957-1958	do.	do.	.7	do.	do.
Panama	1952-1953	do.	do.	.63	do.	do.
Puerto Rico	1952	do.	do.	.80	do.	do.
Yugoslavia	1955	do.	do.	.72	do.	do.

1/ Kuznets, Simon. "Quantitative Aspects of the Economic Growth of Nations: VII The Share and Structure of Consumption." Economic Development and Cultural Change, Vol. 10, No. 2, part 2, pp. 80-89. Jan. 1962. A correlation analysis was made and unity added to the Engel Curve elasticity to obtain the elasticity of the consumption function. See the discussion of methods later in the chapter.

2/ Burk, Marguerite C. Trends and Patterns in U.S. Food Consumption. U.S. Dept. Agr. Handbook 214, pp. 25 and 88. 1961.

3/ This equation includes X_3 which is retail food prices divided by the consumer price index in order to compensate for changes in the relative price of food.

4/ Burk, Marguerite C. Some Analysis of Income-Food Relationships. Jour. Amer. Statist. Assoc. 53: 915. Dec. 1958.

5/ Goreux, L. M. Income Elasticity of the Demand for Food. UN Econ. Commission for Europe (in coop. with FAO) AGRI/WP 7/2, June 1959 (mimeo.) Table B-12.

6/ FAO State of Food and Agriculture. p. 86. Rome. 1957.

food. For other countries the time series elasticities in the table vary from a high of .96 for Italy down to .52 for Norway. Part of the differences in the elasticities reflect varied cultural and economic environments in the nations. Also, there probably are some spurious influences in some of these data due to measurement problems. 8/

The lack of data for time series analysis in many nations has caused economists to seek estimates of the income elasticity of food consumption from cross-section budget studies. Representative estimates of food elasticities from cross-section budget study analyses are also given in table 2 for comparison with the time series elasticities. Again the range of the elasticities is very great, with some tendency for the elasticities to be high in low-income countries and lower in high-income countries.

Further, perspective on values for the income elasticity of food from budget studies is given by a large number of income elasticity estimates made by the Food and Agriculture Organization of the United Nations. A summary of these data show an income elasticity of food of approximately .8 when total expenditures are about \$50 per capita per year. The elasticity decreases to about .5 for the nonfarm population and to about .4 for the farm population at the \$1,000 per capita income level (Goreux 27, p. 6). The fact that these budget study elasticities decrease as income rises, lends weight to the view that the income elasticity of Total Food decreases as per capita income rises. Equally important, however, is the fact that the decrease in the income elasticity of Total Food given here, especially for the nonfarm population, is exceedingly gradual over very great changes in per capita income. 9/

The somewhat uncertain empirical results obtained from time series and budget study analysis suggest turning to theory for guidance, especially to determine the relation between time series elasticities and cross-section budget study elasticities. Wold and Jureen state that time series and budget study elasticities are not the same conceptually. In addition, they show that budget study elasticities should be smaller than time series elasticities (56, p. 230). If this theory is sustained, budget study elasticities might be used to indicate minimum income elasticities for food, but they could not be relied upon for estimates of the elasticity of food during development. 10/

8/ For additional discussion of some of the possible effects of measurement difficulties on estimates of elasticities see Kuznets (36, p. 40-41).

9/ Major references to the very large number of analyses of family budget studies not already mentioned include: Snyder (46), Rockwell (44), Fox (23), Prais and Houthakker (43), Clark et al (12), and Wetmore et al (55). Mitchellson and Brown (1) propose the use of a sigmoid response curve in budget study analyses. This curve includes the concept of a saturation level.

10/ Crockett (16) in her discussion of time series and cross-section estimates of the income elasticity of food is not in agreement with Wold. A recent discussion of aspects of this problem with reasons for some of the differences obtained from budget studies and time series analysis was given by Anderscheid (38).

International Comparisons

International comparisons of Engel Curve data provide more convincing evidence on the general magnitude of the income elasticity of Total Food during development. Engel stated "...the poorer a family is, the greater the proportion of the total expenditures which must be used to procure food." ^{11/} This relation between the proportion of expenditures for food and income is Engel's law proper. The term Engel Curve will be used for this relation throughout this report. The closely associated relation between food expenditures and income will be called the food consumption function, to agree with much of the literature. ^{12/}

We will first discuss the Engel Curve proper on the basis of evidence from international comparisons. The second step will be to investigate the implications of the Engel Curve analysis for the income elasticity of Total Food on the food consumption function.

The Engel Curve for Food

An analysis of the Engel Curve for food was made with data for 35 countries at two points in time, 1953 and 1960. The data show the ratio of food expenditure to Private Consumption Expenditure compared with Private Consumption Expenditure per capita (fig. 3). Perhaps the first thing to note is that the highest ratio of food expenditures to all expenditures is about 70 percent while the lowest ratio approaches 20 percent. Kuznets after a similar analysis of international comparison data used the limits of 60 percent and 20 percent for the ratio of food expenditures to all expenditures as representative of the general international range in the structure of private consumption expenditures for food (36, p. 27).

In making statistical analysis of these data careful consideration was given to the mathematical functions which might be used in a least squares regression. Double logarithmic and semilogarithmic functions were chosen as having suitable characteristics and because they have been used very often in the literature. ^{13/} The trend of these data is shown by the regression equations and two lines in figure 3. High correlation coefficients of about .9 were obtained for both equations (table 3). The semilogarithmic function,

^{11/} As quoted by Burk (5, p. 115).

^{12/} Some confusion is caused by some writers who use the term Engel Curve for both the food consumption function and the Engel relation proper.

^{13/} It is recognized that the mathematical functions chosen here are only representative of a large number of functions, most of which are of much greater complexity. Given the quality of the data and the nature of the relationships, it is doubtful that further effort to test other functions at this time would contribute significantly to the results obtained. Discussion of the characteristics of a number of functions of possible usefulness in analyzing Engel Curves are given by Goreux (27) and also by Prais (42).

AN ENGEL CURVE OF FOOD EXPENDITURES BASED ON INTERNATIONAL COMPARISONS *

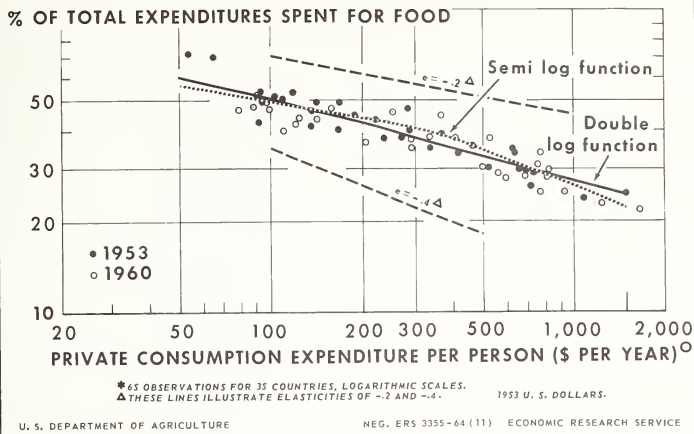


Figure 3

which is a curve on double logarithmic graph paper, might be preferred because its decreasing elasticity fits some of the evidence better. The income elasticity of this function it will be noted decreases from approximately $-.2$ at the 50 per capita Private Consumption Expenditure level to $-.4$ at the \$1,000 expenditure level. The elasticity of the double logarithmic function is a constant $-.27$. An income elasticity of the Engel Curve of $-.27$ may be interpreted as follows: If there is a 10-percent increase in income there will be 2.7-percent decrease in the ratio food expenditure divided by total expenditures. ^{14/}

Data from other sources also support the general magnitude of these Engel curve elasticities. For example, a figure showing 11 countries was given by

^{14/} The elasticities and shapes of the function in this analysis were supported by a similar analysis of other data for 13 countries from an entirely different source. The double logarithmic function in this case was estimated as $\log \frac{Y}{E} = .3336 - .2854 \log E$ ($r = .93$) and the semilogarithmic function as $\frac{Y}{E} = 1.1683 - .2934 \log E$ ($r = .94$). The elasticity of this semilogarithmic function changes in almost the same way as the semilogarithmic function given in table 3, being $-.19$ at \$50 per capita expenditures and decreasing to $-.44$ at \$1,000 per capita expenditures. It will be noted also that the elasticity of the double logarithmic function of $.28$ is very close to the elasticity of $-.27$ in the previous double logarithmic equation. Source of data: Goreux (29, p. 17 and 18).

Table 3.--Estimated Engel curves and derived food consumption functions from international comparisons using data for 35 countries with 65 observations 1953 U.S. dollars 1/

ESTIMATED ENGEL CURVES				
Private consumption expenditure per capita	Double logarithmic function		Semi-logarithmic function	
	$\text{Log } \left(\frac{F}{E} \times 100 \right) = 2.2399 - .2683 \text{ Log } E$		$\left(\frac{F}{E} \times 100 \right) = 98.39 - 24.02 \text{ Log } E$	
	$r = .91$		$r = .89$	
E	The ratio of food expenditure to private consumption expenditure	Elasticity of food consumption expenditure	The ratio of food expenditure to private consumption expenditure	Elasticity of food consumption expenditure
	$\frac{F}{E} \times 100$	$e = b$	$\frac{F}{E} \times 100$	$e = .4343 \frac{b}{100} \frac{E}{F} \frac{2/}{}$
Dollars	Percent		Percent	
50	60.8	-.27	57.6	-.18
100	50.5	-.27	50.4	-.21
200	41.9	-.27	43.1	-.24
500	32.8	-.27	33.6	-.31
1,000	27.2	-.27	26.3	-.40
1,500	24.4	-.27	22.1	-.47
DERIVED FOOD CONSUMPTION FUNCTIONS				
E	Double logarithmic consumption function derived from the double logarithmic Engel curve		Complex consumption function derived from the semilogarithmic Engel curve	
	$\text{Log } F = 2.2399 - \text{log } 100 + (-.2683 + 1) \text{ Log } E$		$F = \frac{E}{100} (98.39 - 24.02 \text{ Log } E)$	
	F	$e = b + 1$	F	$e = .4343 \frac{b}{100} \frac{E}{F} + 1 \frac{2/}{}$
Dollars	Dollars		Dollars	
50	30	.73	29	.82
100	50	.73	50	.79
200	84	.73	86	.76
500	164	.73	168	.69
1,000	272	.73	263	.60
1,500	366	.73	332	.53

1/ Where possible two observations were included for each country in the regression analysis, one for 1953 and one for 1960. If data included beverages, the average of 9 percent of expenditure for beverages in other countries was subtracted to obtain an estimate of food expenditures. Official exchange rates were used. See Appendix 3.

2/ For proof of the relation between the elasticity of the consumption function and the one for the Engel curve, see footnote 18, p. 24. b in this case equals -24.02.

att comparing food as a percent of total consumption expenditures with per-
nal consumption expenditure per capita in U.S. 1960 dollars based on pur-
asing power exchange rates. In this figure there are 8 to 10 annual obser-
ations for each country between the years 1950 and 1960. A visual line of
st fit for this figure provides an elasticity of approximately $-.39$ on the
gel Curve. In a study by Brown (3, p. 42 and 44) similar data were develop-
using different exchange rates. These data provide a regression curve
asticity on the Engel Curve of $-.27$. Data for 13 developed Atlantic commun-
y countries given by Cappock (15) have an Engel Curve elasticity of $-.32$.
d finally, analysis of Kuznets' international comparisons data provide an in-
me elasticity for food on the Engel Curve of $-.25$ (36, p. 24).

Further consideration of figure 3 shows that it is unlikely, over the
ry long run, for a country to have an elasticity on the Engel Curve very
fferent from $-.3$. This can be seen by observing the two dashed lines in
e figure which show an elasticity of $-.2$ and $-.4$. 15/ It is clear from
ese lines that if a nation is going to move during development from using
y 50 percent of its expenditures for food at a per capita expenditure level
\$100, to using about 25 percent of its expenditures for food at the \$1,000
er capita expenditure level, the arc or average elasticity must be about $-.3$.
is average, of course, might be obtained from having a combination of an
lasticity of say $-.2$ at lower per capita consumption levels slowly changing
o an elasticity of say $-.4$ at high expenditure levels. Of course, each
country will follow a somewhat different path due to the economic and cultural
onditions prevailing in that nation. Also, during the course of development,
ere will undoubtedly be irregular movements along the Engel Curve. Thus,
uring certain periods the elasticity might remain very high--approaching
ero while during other periods it might become very low. However, during
e long sweep of development, the evidence suggests that approximately $-.3$ is
e general trend of the income elasticity for food on the Engel Curve. 16/

The analysis of the Engel Curve may be pursued further in order to set
extreme limits on the income elasticity of food expenditures during develop-
ent. This can be done by considering the Engel Curves in figure 4. The
iddle heavy line, MP, is an Engel Curve with a constant income elasticity of
 $-.3$. This is the general elasticity obtained from the empirical analysis
iven above. This line is placed so that it represents the general trend of
mpirical data given earlier. Approximately 60 percent of private consumption
penditure is used for food when total expenditures are \$50, and between 24'
nd 30 percent of expenditures are used for food when per capita expenditures
re \$1,000.

In order to set extreme limits for the elasticity of the Engel Curve con-
sider one limit (see line LQ, fig. 4). Some countries might conceivably use

15/ These lines have no other significance except to show visually what
n elasticity of $-.2$ and $-.4$ implies.

16/ In the preceding analysis, estimates of per capita expenditures were
sed instead of per capita income because data on disposable income were not
available. Savings, the difference between expenditures and income, have
herefore been neglected. However, if savings remain about the same propor-
ion of income, the estimates of expenditure elasticities obtained will also
pproximate the income elasticities. For proof see footnote 6 in Chapter 3.

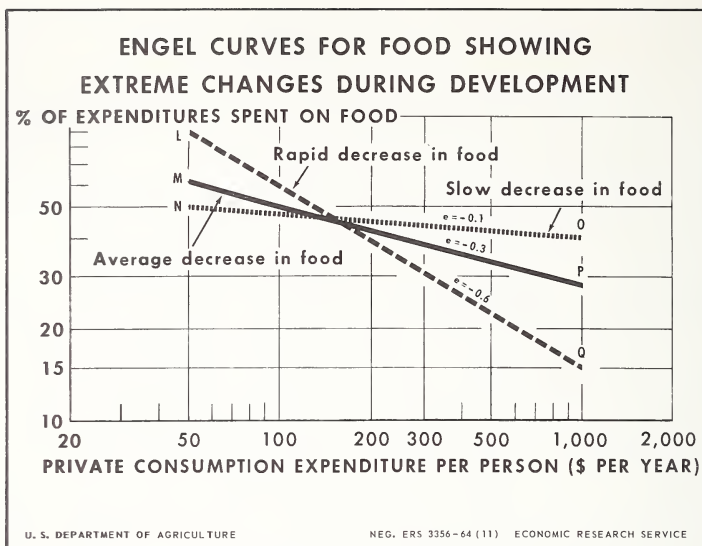


Figure 4

as much as 90 percent of expenditures for food at the \$50 per capita total expenditure level. One can think of tropical island tribal groups where this might be the case. It is conceivable that after a long period of development such societies might use as little as 15 percent of their expenditures for food when total expenditures are \$1,000. A society which followed this pattern would have an average elasticity for the Engel Curve for food of about -0.6 .

The other development extreme may also be set. In this case, the proportion of food expenditures to total expenditures decreases very slowly (see line NO, fig. 4). The assumption is made here that some society might spend about 50 percent of total expenditures for food at the \$50 per capita income level, and that it would decrease this percentage very slowly to 40 percent at \$1,000 per capita total income. If this extreme Engel Curve were true for a society, the average elasticity would be -0.1 . We may therefore say that -0.6 and -0.1 are the two extreme elasticity limits for food on the Engel Curve during the long sweep of economic development.

The Food Consumption Function

We turn here to the implications of the Engel Curve Analysis just completed for the income elasticity of Total Food on the consumption function. Up until now, we have been considering the Engel Curve which relates the proportion of expenditures used for food and total expenditures. We now turn to

the food consumption function, the relation between food expenditures and total expenditures. It is obvious that the Engel Curve for food is closely related to the consumption function for food. One curve may in fact be derived from the other. Proof of this can be obtained by deriving food consumption functions from the Engel Curves obtained earlier. The derived equations were given in table 3. They are also shown in figure 5. ^{17/} Of interest is the fact

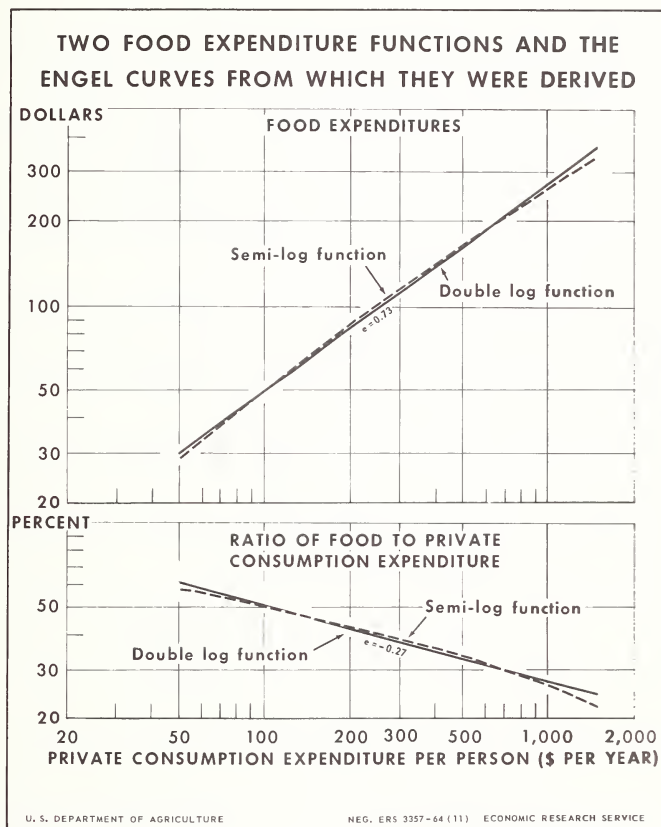


Figure 5

^{17/} The derivation of the consumption function from the double logarithmic Engel Curve is as follows: $\log \frac{F}{E} = \log a + b \log E$, or $\log F - \log E = \log a + b \log E$ and therefore $\log F = \log a + (b + 1) \log E$.

that the consumption function derived from the double logarithmic Engel Curve remains a double logarithmic function. However, the consumption function derived from the semilogarithmic Engel Curve becomes a more complex function. The elasticity of food expenditures obtained from the derived double logarithmic consumption function is a constant .73. If instead a double logarithmic regression analysis is made of the consumption function based on these same data, the same results are obtained. The function derived from the semilogarithmic Engel Curve has an income elasticity of food expenditure which ranges from .82, when per capita expenditure is \$50, to .60 at \$1,000 per capita total expenditures.

For the purposes of this study the most important relation between the Engel Curve and the food consumption function is that there is found to be a difference of only unity between the income elasticity for food on the Engel Curve and the income elasticities for food on the consumption function. This relation is independent of the mathematical form of the equation used. Thus, an elasticity on the Engel Curve is transposed to the corresponding elasticity on the consumption function by the addition of unity. The subtraction of unity from the consumption function elasticity provides the elasticity for the Engel Curve. 18/ This fact is illustrated in table 3 where the elasticity of the double logarithmic Engel Curve is -.27 and the elasticity of the corresponding food consumption function is .73.

A useful side result of the direct relation between the Engel Curve and the consumption function is that if the change in the shares on the Engel

18/ Proof that the difference between the two elasticities is unity can be given as follows:

Since by definition the elasticity of the Engel Curve, e_E , is:

$$\begin{aligned}
 e_E &= \frac{\frac{\text{Log } (F_2)}{E_2} - \frac{\text{Log } (F_1)}{E_1}}{\text{Log } E_2 - \text{Log } E_1} \quad \text{then} \\
 &= \frac{\text{Log } F_2 - \text{Log } E_2 - \text{Log } F_1 + \text{Log } E_1}{\text{Log } E_2 - \text{Log } E_1} \\
 &= \frac{\text{Log } F_2 - \text{Log } F_1}{\text{Log } E_2 - \text{Log } E_1} - 1
 \end{aligned}$$

As the first term of this equation is the elasticity of the consumption function, e_C , therefore $e_E = e_C - 1$.

Curve of any commodity is known in relation to the change in income, the income elasticity of that commodity on the consumption function may be easily obtained. Thus, for example, if the ratio of food expenditures decreases from 50.6 percent to 27.2 percent as total expenditures go from \$100 to \$1,000 as in table 3, the constant or average food expenditure elasticity on the consumption function is easily found to be .73. 19/

Using the preceding analysis of the Engel Curve and Food consumption function, one can conclude that the long-run income elasticity of the food consumption function is somewhere near .7. Reasonable limits for the income elasticity of the food consumption function can be obtained from the corresponding limits previously obtained for the Engel Curve. With the addition of unity to the income elasticity limits obtained above for the Engel Curve, limits of .9 down to .4 for the consumption function are obtained. These limits were developed as extreme possibilities for the long-run elasticities for food as explained above. The range of probable long-run elasticities is much less in the per capita income ranges considered.

This conclusion about probable elasticities on the consumption function is supported by Kuznets' results for long-run expenditure elasticities for total food in Sweden and the United States. For Sweden, from 1871-80 to 1921-30, the elasticity for food was .72, while for the United States, from 1869 to 1949-57, the elasticity was .78 (36, p. 47).

Some implications of the elasticities obtained in this chapter for per capita food consumption levels are given in table 4. Examples of per capita food consumption levels are shown which would occur at different total expenditure or income levels with the income elasticities of Total Food varying from .9 down to .4. The data were calculated under certain assumptions about the initial level of food consumption and with the use of the double logarithmic function which has a constant income elasticity. For example, if some countries with \$50 per capita total expenditures use 70 percent of their expenditures for food, the per capita level of food consumption would be \$35. Then assuming, that the effective long-run expenditure elasticity of food is .7, the following per capita amounts of food will be consumed as income rises: at the \$200 per capita expenditure level, \$92 worth of food; at the \$500 per capita expenditure level, \$175 worth of food; and at the \$1,000 per capita expenditure level, \$285 worth of food. Two other levels of food consumption resulting from different elasticity assumptions and initial ratios of consumption are also indicated. The extreme levels of food consumption shown in the table are obviously very unlikely possibilities.

In summary, the analysis in this chapter indicates that the long-run income (or expenditure) elasticity for Total Food is not far from .7. Limits for the long-run income elasticity of Total Food obtained ranged from an upper limit of .9 down to a lower limit of .4. These limits rule out as very unlikely long-run income elasticities of Total Food beyond these magnitudes.

19/

$$\frac{\text{Log } 27.2 - \text{Log } 50.6}{\text{Log } 1,000 - \text{Log } 100} = -.27. \quad -.27 + 1 = .73.$$

Table 4A.--Per capita food consumption at different total expenditure levels with various expenditure elasticities for food and three initial ratios of expenditures used for food ^{1/}

Initial ratio of expenditures for food to total expenditures	Total expenditures per capita	Expenditure elasticities for food as follows:					
		.9	.8	.7	.6	.5	.4
Percent	Dollars	Dollars					
90	50	45	45	45	45	45	45
	200	157	136	119	103	90	78
	500	357	284	226	179	142	113
	1,000	667	494	366	271	201	149
70	50	35	35	35	35	35	35
	200	122	106	92	80	70	61
	500	278	221	175	139	111	88
	1,000	519	384	285	211	157	116
50	50	25	25	25	25	25	25
	200	87	76	66	57	50	44
	500	199	158	125	100	79	63
	1,000	370	275	203	151	112	83

^{1/} These data were developed using the following equation: $\log V = \log a + e \log E$, and the food and expenditure assumptions specified.

Table 4B.--Percent food expenditures are of total expenditures per capita at different per capita expenditure levels with various expenditure elasticities for food and three initial ratios of expenditures used for food ^{1/}

Initial ratio of expenditures for food to total expenditures	Total expenditures per capita	Expenditure elasticities for food as follows:					
		.9	.8	.7	.6	.5	.4
Percent	Dollars	Percent					
90	50	90	90	90	90	90	90
	200	78	68	60	52	45	39
	500	71	57	45	36	28	23
	1,000	68	49	37	27	20	15
70	50	70	70	70	70	70	70
	200	61	53	46	40	35	30
	500	56	44	35	28	22	18
	1,000	52	38	28	21	16	12
50	50	50	50	50	50	50	50
	200	44	38	33	28	25	22
	500	40	32	25	20	16	13
	1,000	37	28	20	15	11	8

^{1/} These data calculated from table 4A.

The preceding chapter was the first of three chapters focused on assembling and analyzing the data needed to obtain estimates of the income elasticity of Food at Retail. It provided income elasticities for Total Food. The present chapter focuses on obtaining estimates of changes in the ratio of Food at Retail to Total Food during development. The subsequent chapter provides estimates of the income elasticity of Food at Retail.

For low-income countries, there are essentially no data available on the changes in the ratio of Food at Retail to Total Food associated with changes in per capita income. Thus, an indirect approach was required to obtain estimates of this ratio. The procedure adopted was to establish three possible long-run changes in the ratio of Food at Retail to Total Food as economic development occurs. One path, called the Medium Retail Food Path, is developed on the basis of labor force data and certain assumptions. The other two paths, the High and Low Retail Food Paths, were developed on the basis of more extreme assumptions about the changes in the ratio of Food at Retail to Total Food.

The Medium Retail Food Path was obtained in the following way. Since rough estimates of the nonagricultural labor force are available for many countries, it was assumed that the ratio of nonagricultural labor to the total labor force indicated approximately the proportion of Food at Retail to Total Food. The justification for this assumption is based on the following argument. In low-income countries a high proportion of the food produced by the labor force in agricultural occupations is consumed as Home-produced Food and a relatively small proportion of food is purchased. The opposite is the case in crowded urbanized areas where a high proportion of Total Food is Food at Retail. It is assumed that the relatively small amount of Food at Retail bought by agricultural laborers and their families is approximately balanced by the amount of Home-produced Food consumed by nonagricultural laborers and their families. If this is the case, the ratio of the nonagricultural labor force to the total labor force would indicate approximately the ratio of Food at Retail to Total Food.

Lack of data on food consumption in low-income countries prevents testing this assumption. However, even if there is some difference, the resulting bias would likely be small and therefore only move the estimates of the ratio of Food at Retail to Total Food a few percentage points either way. Only if there were very great differences between these two amounts would the assumption not be generally valid. Even then, as long as the bias were consistent, the general shifts in the consumption of Food at Retail indicated by the labor force data would occur. It should be remembered in this connection that we are concerned here with gross shifts during a long sweep of development. Thus, an error of a few percentage points will not influence the argument very much.

Two additional aspects are involved in this assumption about the ratio of Food at Retail to Total Food. One is the question as to how agricultural and nonagricultural labor are defined. This is a very complex problem as somewhat

different definitions are used in different countries. For the purpose of this paper, however, as long as there is no consistent bias one way or the other associated with increasing per capita income, the general results of the analysis are not influenced. The other issue concerns the likelihood that the value of average urban per capita food consumption is somewhat greater than the value of rural per capita food consumption, due primarily to higher per capita income in urban areas. If this is the case, the importance of Food at Retail would be somewhat greater and it would increase more rapidly than indicated by the proportion of the labor force in nonagricultural occupations. Under these circumstances the income elasticities for Food at Retail would probably be greater.

Let us turn now to the data used to obtain the Medium Retail Food Path. Grouped data for 70 countries are given in table 5 of the average ratio of the nonagricultural labor force to the total labor force at different levels of per capita income. The five countries with per capita incomes of \$75 or less have an average of about 27 percent of the labor force in nonagricultural occupations. In contrast to this the five nations with per capita incomes of \$950 and above have approximately 85 percent of the labor force in nonagricultural occupations. Individual observations of the labor force ratio in the 70 countries are shown in figure 6. Most of these observations have a reasonable variation from the trend. The averages for the income groups given in table are also indicated in the figure.

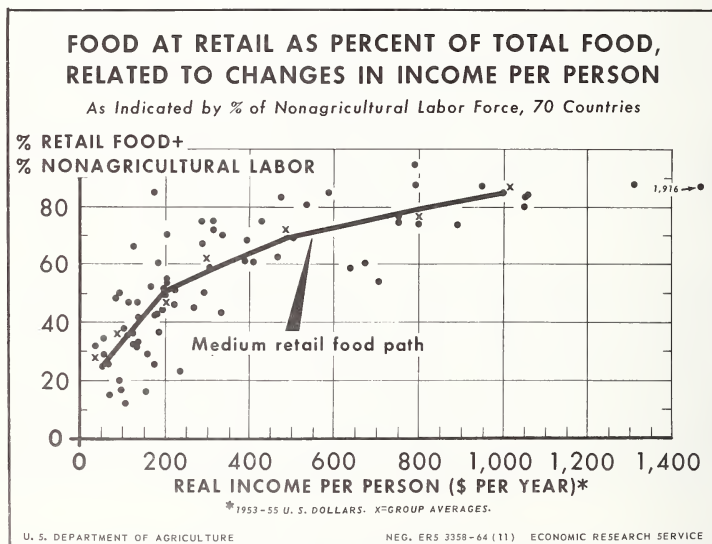


Figure 6

Table 5.--Percentage of total labor force employed in nonagricultural occupations associated with different levels of per capita income, 70 countries.

Per capita income 1953-55	Countries	Total labor force employed in nonagricultural occupations	
		Average	Assumed percentages for the Medium Retail Food Path
S. dollars	Number	Percent	Percent
950 and above.....	5	85	85
949-650.....	9	76	
649-350.....	9	71	70
349-250.....	9	61	
249-150.....	17	46	50
149-75.....	16	37	
75 and below.....	5	27	25

Source: Appendix 4.

The Medium Retail Food Path is shown by the line in figure 6. It represents changes in the ratio of Food at Retail to Total Food as per capita income increases. This path is based on only four points, given in the last column of table 5. The line therefore, slightly simplifies the trend of the data. This simplification permits considerably greater clarity and ease in developing the analysis of this bulletin in later chapters, while at the same time the modification does not influence the general conclusions. The Medium Retail Food Path derived in this way indicates that at the \$50 per capita income level, about 25 percent of Total Food is Food at Retail. This proportion increases to about 50 percent at the \$200 per capita income level, increasing to about 70 percent at an income of \$500 per capita, and to around 85 percent at \$1,000 per capita. Data for individual countries will, of course, vary considerably from the Medium Retail Food Path. Due to national, economic, and cultural influences variations in food consumption will occur in individual countries. However, the general progression of the changes appears to be reasonable. Of particular interest is the fact that this Retail Food Path appears to suggest a relatively more rapid increase in the proportion of Food at Retail at lower income levels than at higher income levels.

Data on the relative importance of Food at Retail in the United States, when measured approximately as defined in this study, supports the location of the Medium Retail Food Path at the high income end. In the years around 1940, when U.S. per capita income was about \$1,000 in 1947-49 dollars, Food at Retail represented approximately 92 percent of the value of Total Food. 20/

Two other paths for the ratio of Food at Retail to Total Food were considered to show extreme possibilities (fig. 6). The high Retail Food Path assumes that Food at Retail accounts for 60 percent of Total Food when income

20/ See Burk (7, p. 42), TFW-11b divided by TFW-10b.

per capita is \$50. This path rises to 95 percent of Food at Retail when per capita income is \$1,000. This path might be followed by certain low-income countries in South Asia that depend upon rice as their staple food. This is perhaps most likely in a country where a major proportion of food is imported such as in Ceylon.

The Low Retail Food Path in the figure assumes that 10 percent of Total Food is Food at Retail at the \$50 per capita income level. The ratio increases to 75 percent at the \$1,000 per capita income level. This path appears to be a possibility in some equatorial regions where hunting and gathering are predominant in tribal or island economies.

The results obtained in this chapter are summarized in figure 7 and table 6. Perhaps the most interesting general result of this analysis is that there appears to be a much more rapid increase in the ratio of Food at Retail to Total Food at lower per capita income levels than at higher levels.

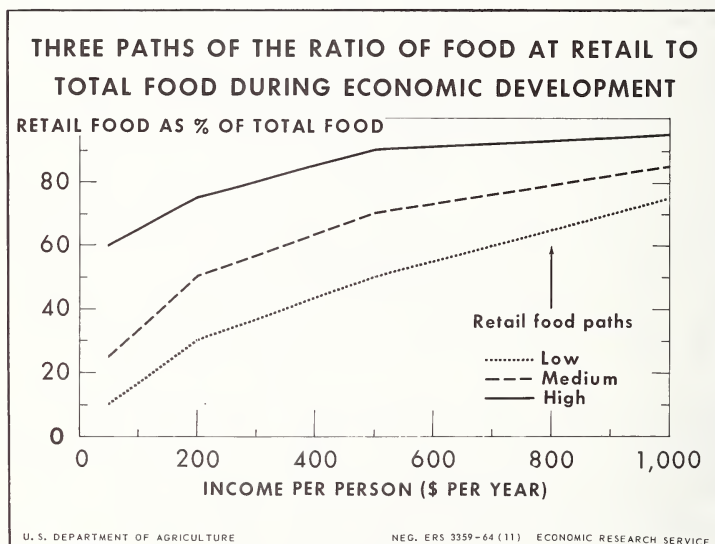


Figure 7

Table 6.--The ratio of Food at Retail to Total Food, W_R , at specified levels of income per capita on the three Retail Food Paths 1/

Retail Food Path	Ratio of Food at Retail to Total Food with per capita income as follows:			
	\$50	\$200	\$500	\$1,000
	Percent	Percent	Percent	Percent
Low.....	10	30	50	75
Medium.....	25	50	70	85
High.....	60	75	90	95

1/ The Low, Medium and High Retail Food Paths each represent shifts in the ratio of Food at Retail to Total Food as countries undergo economic development and experience higher levels of per capita income.

Chapter VI. -- THE INCOME ELASTICITY OF FOOD AT RETAIL DURING DEVELOPMENT

In this chapter we draw together the results from the previous two chapters to estimate the income elasticity of Food at Retail during development. In Chapter 4 reasonable limits for the income elasticity of Total Food were considered. In the last chapter the changes in ratio of Food at Retail to Total Food as per capita income increases were analyzed.

Our focus in this chapter is on the income elasticity of Food at Retail (e_R) which results from various combinations of the independent variables. The independent variables are: The income elasticity of Total Food (e_A), changes in the ratio of Food at Retail to Total Food (W_R), and changes in per capita income (I). The mathematical relations between these variables were given in Chapter 3. It should be recognized that we are treating the elasticity of Food at Retail as the dependent variables for purposes of showing the relation between the elasticity. In fact, consumer decisions are likely to influence both Total Food and Food at Retail elasticity at the same time. Looking at the relation another way, if one had good estimates of the elasticity of Food at Retail, estimates of the elasticity of Total Food might be made.

The equation shows that the greater the increase in the ratio of Food at Retail to Total Food, relative to the change in income, the more the income elasticity of Food at Retail will exceed the income elasticity of Total Food. The last term in this equation is the elasticity of the proportion (W_R). Thus one may say, the greater the income elasticity of the proportion, the greater will be the influence between the income elasticities of food. In the obverse sense, if there is essentially no change in the proportion of Food at Retail to Total Food (the elasticity of the proportion, W_R , is zero), the term e_{W_R} drops out, and the income elasticity of Food at Retail is the same as the income elasticity of Total Food.

The amount by which the income elasticity of Food at Retail is greater than the elasticity of Total Food under specified assumptions is shown in

table 7. The values in this table are for the elasticity of the proportion W . It will be remembered that the Low Retail Food Path had the greatest relative change in the proportion of Food at Retail to Total Food (table 6). Thus on this path, for a given change in per capita income the value of e_{W_R} is high and therefore, the difference between the two elasticities is large. For example, consider the per capita income changes from \$50 to \$200 on the Low Retail Food Path (fig. 7). There is a relatively great increase in the ratio of Food at Retail to Total Food on this path, thus the elasticity of Food at Retail exceeds the elasticity of Total Food by .79. However in this income range, on the High Retail Food Path, the proportion of Food at Retail increases rather slowly. In this case e_R exceeds e_A by only .16. We see therefore, that the greater the changes in the ratio W_R , the greater the difference between the two elasticities.

Table 7.--The amount by which the income elasticity of Food at Retail, e_R , is greater than the elasticity of Total Food, e_A , for specified changes in per capita income on the three Retail Food Paths

Retail Food Path	The value of e_{W_R} with income changes as follows:		
	$1/$	\$50 to \$200	\$200 to \$500 : \$500 to \$1,000
Low.....	.79	.56	.58
Medium.....	.50	.37	.28
High.....	.16	.20	.08

1/ The Low, Medium and High Retail Food Paths each represent shifts in the ratio of Food at Retail to Total Food as development occurs. For example, in the case of the Medium Retail Food Path when income per capita increases from \$50 to \$200, and the ratio of Food at Retail to Total Food increases from 25 percent to 50 percent, e_R is .50 greater than e_A . For discussion of the Retail Food Paths see Chapter 5.

Looking at table 7 as a whole, note that the greatest differences between the elasticity of Food at Retail and Total Food are in the lowest per capita income range. This is because the ratio of Food at Retail to Total Food is increasing relatively more rapidly at this income level and hence the elasticity of the proportion W_R has higher values. Thus it appears that the income elasticity of Food at Retail will be greatest in the early stages of development.

Now if we add the income elasticities for Total Food found in Chapter 4 to the values in table 7, a series of elasticities for Food at Retail are obtained for the different food paths (table 8). The large range of elasticities for Total Food, from .9 to .4, is presented so as to cover the extreme limits for the income elasticity of Food at Retail. The most likely elasticities for Food at Retail will, however, be obtained from using elasticities for Total Food close to .7.

The most striking general fact about the elasticities for Food at Retail in table 8 is that most of them are higher than those usually seen. Many of

Table 8.--Income elasticities for Food at Retail on the three Retail Food Paths, assuming certain elasticities for Total Food and specified changes in per capita income

Change in per : Retail Food :		Income elasticity of Total Food					
capita income :	Path 1/	.9	.8	.7	.6	.5	.4
Dollars		- - - -	- Retail Food elasticities -	- - - -			
0-200	: Low.....	1.69	1.59	1.49	1.39	1.29	1.19
	: Medium.....	1.40	1.30	1.20	1.10	1.00	.90
	: High.....	1.06	.96	.86	.76	.66	.56
100-500	: Low.....	1.46	1.36	1.26	1.16	1.06	.96
	: Medium.....	1.27	1.17	1.07	.97	.87	.77
	: High.....	1.10	1.00	.90	.80	.70	.60
500-1,000	: Low.....	1.48	1.38	1.28	1.18	1.08	.98
	: Medium.....	1.18	1.08	.98	.88	.78	.68
	: High.....	.98	.88	.78	.68	.58	.48

1/ The Retail Food Paths specify the changes in the ratio of Food at Retail to Total Food (W_R) as income changes. (See Chapter 5.)

The elasticities are greater than 1.0. Also there are only four situations, all on the High Retail Food Path, where the elasticity of Food at Retail is appreciably below .7. This is when Food at Retail is such a high proportion of Total Food that there cannot be much difference between the two elasticities. Looking at table 8 critically, on the basis of general knowledge some of the very high elasticities for Food at Retail obtained on the Low Retail Food Path do not appear to be very likely.

The most important results in this table are the elasticities for Food at Retail which are obtained from the most likely development conditions. Looking at the column in table 8 labeled "Income elasticity of Total Food .7," and the Medium Retail Food Path, the income elasticity of Food at Retail varies from 1.20 down to .98. If, as appears possible, the High Retail Food Path is likely in some countries, the minimum elasticity for Food at Retail is .78 or approximately .8. Thus, on the basis of this analysis, a range of 1.20 down to .8 appears to be a reasonable range for the income elasticity of Food at Retail during development.

Of interest are the income elasticities for Food at Retail obtained if a declining income elasticity of Total Food is accepted. We will use the declining income elasticities given in one of the Goreux studies (27, p. 6). 21/

21/ Jureen's analysis of data from European countries supports a decline in the income elasticity of all food as incomes increase. His elasticities, however, are generally much lower than the Goreux (27) and Kuznets (36) elasticities starting at about .55 and then decreasing to about .1.

The Goreux study is based on cross-section analysis. It indicates an income elasticity for Total Food of about .7 up to per capita incomes of \$200. Between \$200 and \$500 per capita income, the elasticity is in the neighborhood of .6 while above \$500 per capita, the elasticity drops to around .5. With these assumptions if we note the Medium Retail Food Path in table 8 with an elasticity for Total Food of .7, the elasticity for Food at Retail is 1.20 in the \$50 to \$200 per capita income range. Dropping diagonally to the right, a Food at Retail elasticity of .97 is seen in the middle per capita range, while a Food at Retail elasticity of .78 appears at per capita incomes above \$500 when the Total Food elasticity is .5.

There is an additional relation to observe on the Medium Retail Food Path. If the income elasticity of Total Food remains unchanged on this path as incomes rise, the income elasticities for Food at Retail decline. For example, assuming a Total Food elasticity of .7, the Food at Retail elasticities are 1.20, 1.07, and .98. There is also some decline in Food at Retail elasticities on the other two Retail Food Paths. The reason for the decline is that the proportion W_R changes less rapidly at high incomes. These results suggest a contributory explanation for the decline in the income elasticity of Food at Retail obtained in some time-series studies.

The relation between the income elasticity of Total Food and Food at Retail may be observed in another way. In the equation on which this chapter is based for a given change in per capita income the ratio of Food at Retail to Total Food will increase, thereby increasing the value of e_{W_R} and hence, the difference between the elasticities of Total Food and Food at Retail. This relationship is shown in table 9 where a doubling of per capita income is assumed. As the value of e_{W_R} is influenced by the initial ratio of Food at Retail to Total Food, this initial ratio is specified in the first column. The other four columns give the percentage point increase in the ratio of Food at Retail to Total Food. Obviously, the greater the change in the ratio,

Table 9.--The amount by which the income elasticity of Food at Retail, e_R , is greater than the elasticity of Total Food, e_A , when per capita income is doubled, and specified increases in the ratio of Food at Retail to Total Food occur 1/

The initial ratio: of Food at Retail: to Total Food :	The percentage point increase in the ratio of Food at Retail to Total Food			
	1	5	10	20
Percent :	-Value of e_{W_R} -			
10.....:	.14	.58	1.00	1.58
30.....:	.05	.22	.42	.74
50.....:	.03	.14	.26	.49
70.....:	.02	.10	.19	.36
90.....:	.02	.08	.15	.29

$$\frac{1/}{\text{Calculated from}} \frac{\log W_{R2} - \log W_{R1}}{\log 2 I - \log I}$$

the greater the difference between the elasticities. The table can be read as follows: If while per capita income doubles, the ratio of Food at Retail to Total Food increases 10 percentage points from 30 percent to 40 percent, the income elasticity of Food at Retail will be .42 greater than the income elasticity of Total Food. However, if Food at Retail initially accounted for a higher proportion of Total Food, say 70 percent, and this ratio increased 10 percentage points, the difference between the elasticities would be only .19.

The way the elasticities of Food at Retail work out in terms of per capita consumption of food are illustrated in table 10. For example, Total Food at the \$50 per capita income level is set at \$35 or at 70 percent of income. An income elasticity for Total Food of .7 was assumed. By using the elasticities from this chapter, estimates of the consumption of Food at Retail per capita are obtained. Thus, the initial point for the projection of per capita food consumption is \$35 worth of Total Food (point A, fig. 8).

The per capita levels of Total Food rise to \$92 at a per capita income of \$200, to \$175 at \$500 per capita income, and to \$285 or 28.5 percent of income at the \$1,000 per capita income level. The projection of Total Food was made by using the double logarithmic function. The data for the Low, Medium, and High Retail Food Paths were obtained by applying the ratios given in table 6 to the estimate of Total Food.

Focusing on the Food at Retail lines first, each of the three lines is seen to close the gap between Total Food and Food at Retail. Food at Retail is thus becoming a higher and higher proportion of Total Food as income increases.

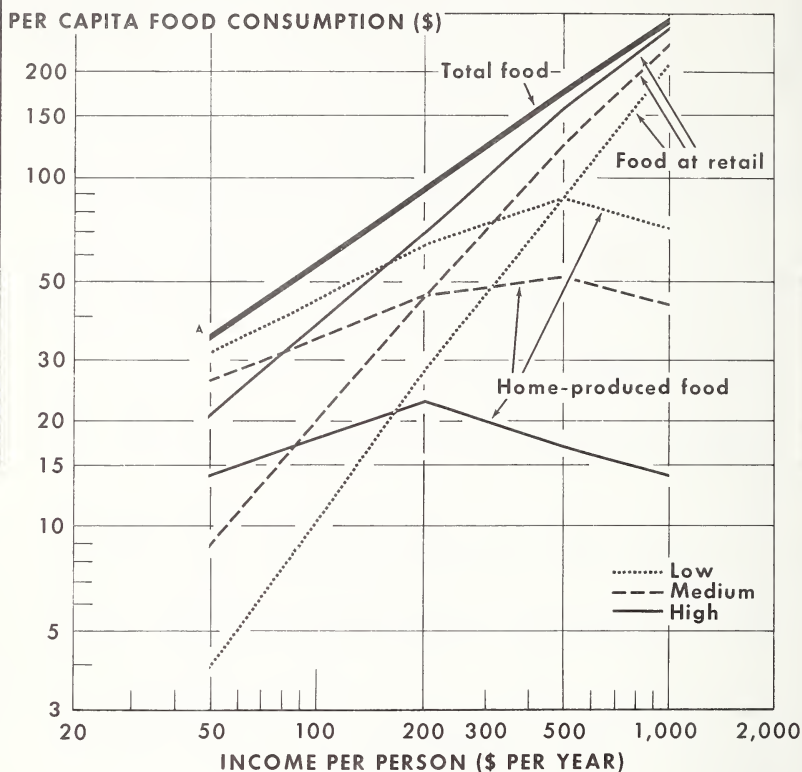
The Home-produced Food lines in the figure are of particular interest. First, it is perhaps surprising that all three Home-produced Food lines rise before falling. How can per capita Home-produced Food consumption increase with rising incomes? As incomes increase it is likely that more preferred and higher quality, hence higher valued, Home-produced Foods will be produced and consumed. Thus a certain increase in the value of Home-produced Food per capita is not unlikely. However, it is not likely that this increase will be as great and continue to such high income levels as is suggested in the high Home-produced Food Path. Experience in the United States supports an increase in the per capita value of Home-produced Food even at high income levels. It was not until after World War II that the "Farm value of Home-produced Foods" (TFV-2) per capita decreased in the United States (Burk,7).

The per capita values of food consumed in figure 8 are given in the center section of table 10. In this table two other more extreme sets of food consumption estimates are given, assuming different income elasticities for Total Food. The high elasticity of .8 and a low elasticity of .5 are included for Total Food. In making these estimates the same point of origin was used. If the point of origin were changed, the estimates would be somewhat different, although the same general picture would emerge.

To summarize this table, it shows the levels of per capita consumption which are implied by the elasticities for Food at Retail given in table 8. The projections provide a range of estimates of per capita food consumption

THREE CONSUMPTION PATHS OF TOTAL FOOD

*Food at Retail and Home-Produced Food,
Related to Changes in Income Per Person*



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Figure 8

which might occur. It is apparent, however, that the highest and lowest levels of food consumption in this table are extremes not likely to be found.

The analysis in this chapter shows that substantial differences are likely to persist between the income elasticity of Total Food and the income elasticity of Food at Retail, the latter being as much as .2 to .4 greater

Table 10.--The per capita consumption of Total Food, Food at Retail, and Home-produced Food on the three Retail Food Paths, at different levels of per capita income, with specified elasticities for Total Food 1/

Income elasticity of Total Food	Retail Food Path	Measure of Food	Value of food consumption at the following incomes:			
			\$50	\$200	\$500	\$1,000
			-----Dollars-----			
.8	Low	Total Food (V_A)	35	106	221	384
		Food at Retail (V_R)	4	32	110.5	288
		Home-produced Food (V_S)	31	74	110.5	96
	Medium	Total Food (V_A)	35	106	221	384
		Food at Retail (V_R)	9	53	155	326
		Home-produced Food (V_S)	26	53	66	58
	High	Total Food (V_A)	35	106	221	384
		Food at Retail (V_R)	21	80	199	365
		Home-produced Food (V_S)	14	26	22	19
.7	Low	Total Food (V_A)	35	92	175	285
		Food at Retail (V_R)	4	28	87.5	214
		Home-produced Food (V_S)	31	64	87.5	71
	Medium	Total Food (V_A)	35	92	175	285
		Food at Retail (V_R)	9	46	123	242
		Home-produced Food (V_S)	26	46	52	43
	High	Total Food (V_A)	35	92	175	285
		Food at Retail (V_R)	21	69	158	271
		Home-produced Food (V_S)	14	23	17	14
.5	Low	Total Food (V_A)	35	70	111	156
		Food at Retail (V_R)	4	21	55.5	117
		Home-produced Food (V_S)	31	49	55.5	39
	Medium	Total Food (V_A)	35	70	111	157
		Food at Retail (V_R)	9	35	78	133
		Home-produced Food (V_S)	26	35	33	23
	High	Total Food (V_A)	35	70	111	156
		Food at Retail (V_R)	21	52	100	148
		Home-produced Food (V_S)	14	18	11	8

1/ The data were obtained by projecting Total Food from \$35 at the \$50 per capita income level with the use of the equation $\log F = \log a + e_A \log I$. Food at Retail and Home-produced Food were then obtained using the proportions given in table 6. Total income per capita could be replaced by total expenditures per capita in this table.

than the income elasticity of Total Food, particularly during stages of rapid development. This is due to the fact that as per capita income increases, the ratio of Food at Retail to Total Food may increase greatly. In such situations the elasticity of Food at Retail remains considerably higher than the elasticity of Total Food.

On the basis of the elasticities for Food at Retail found in this chapter it is evident that the demand for Food at Retail can be expected to remain high in countries undergoing rapid development. For low-income countries increases in per capita income of \$25 or \$50, increases which would be considered modest amounts for the United States, can mean appreciable increases in the consumption of Food at Retail; because of this, there is likely to be considerable strain on the marketing system during development. 22/

Chapter VII. -- THE INFLUENCE OF CHANGES IN THE MARKETING MARGIN ON THE ELASTICITIES OF FOOD FOR WHOLESALE

Knowledge of the income elasticity of Food at Retail considered in the previous chapter provides the basis for estimating food requirements at the retail level as development occurs. For planning programs of economic development, these requirements must be translated to the Food for Wholesale level--the farm gate and wharf level. Food for Wholesale was defined in this study as Food at Retail minus Marketing Costs. In this chapter, the effect of changes in the marketing margin on the elasticity of Food for Wholesale is examined. This sets the stage for estimates of the income elasticity of Food for Wholesale in the following chapter.

The marketing margin is the ratio of Marketing Costs to value of Food at Retail. A major way the marketing margin changes is through changes in the mix of products that flow through the marketing channels. Generally, there is an increase in the number of products which have a higher proportion of marketing services or costs in them. In this study, it will be remembered that relative prices are held constant, so increases in the marketing margin do not come from this source.

The effects of changes in the marketing margin can be analyzed with the use of the second equation in Chapter 3. Food for Wholesale is considered to be the dependent variable. The full elaboration of the equation shows that if there is no change in the marketing margin, the term e_{Up} drops out and the income elasticity of Food for Wholesale is the same as the income elasticity of Food at Retail. Under these circumstances, it is also true that the income elasticity of Marketing Costs (marketing services) is the same as the elasticity of Food at Retail. (See Appendix 2 for further elaboration of these points.)

How the income elasticity of Food for Wholesale differs from the elasticity of Food at Retail depends upon how the marketing margin changes with

22/ Some aspects of the material discussed in this chapter were presented earlier (Stevens, 48). This article used slightly different terminology from that used here. The results of the analysis are the same however.

conomic development and rising incomes. Data from U.S. experience suggest the magnitude of changes in the marketing margin which may occur (table 11). According to these data, the ratio of Marketing Cost to expenditures for all foods declined 3.6 percent from 62.4 to 58.8 percent during the period from 1934 to 1939. In the period from 1944 to 1949, a major reverse took place in the heretofore declining marketing margin as the American public began demanding more services with their foods. In the next 5-year period ending in 1954, while per capita income increased only 5 percent, the marketing margin increased 4.5 percent. In 1954 the marketing margin was about the same as it was in 1934. 23/

table 11.--An example of changes in the marketing margin in the United States 1929-1959. Current Dollars, based on Burk (7)

Year	Food for Wholesale per capita	Expenditures for all foods per capita	Marketing Costs per capita (Col. 3 Col. 2)	Marketing Margin (Col. 4 ÷ Col. 3)	Percentage point change
1/	2/	3/			
(1)	(2)	(3)	(4)	(5)	(6)
		<u>Dollars</u>		<u>Percent</u>	<u>Percent</u>
1934...	47.4	126.1	78.7	62.4	-3.6
1939...	60.3	146.3	86.0	58.8	-2.8
1944...	98.6	224.0	125.4	56.0	+0.9
1949...	135.1	313.6	178.5	56.9	+4.5
1954...	140.1	362.7	222.6	61.4	

1/ 11-year overlapping averages centered.

2/ Burk's series TFFV-5 minus TFFV-2, divided by the civilian population.

3/ Burk's series PFFV-11b.

The magnitude of the influence of changes in the marketing margin on the income elasticity of Food for Wholesale can be illustrated by assuming a given increase in per capita income, and by examining the effect of different changes in the marketing margin on the differences between the elasticities of Food at Retail and Food for Wholesale (table 12). In this example, a 20 percent increase in per capita income has been assumed. This increase would result from a growth rate of about 2 percent per year for 10 years--a rate which has been achieved by growing economies. As the initial level of the marketing margin influences the differences in the elasticities, a range of assumptions for the initial marketing margin was necessary.

23/ The assumption in this analysis is that changes in the ratio of Marketing Costs to Food at Retail do not influence the value of Food at Retail purchases per capita. This assumption appears reasonable for small annual changes in this ratio, for it is difficult to understand how consumers could perceive such changes, and thus be able to react to them.

Table 12.--Differences in value of income elasticity between Food for Wholesale and Food at Retail with specified changes in marketing margins when per capita income increases 20 percent

Changes in marketing : margin :	Initial marketing margin percent ^{1/}				
	30	40	50	60	70
Percent increase :	Elasticity of Food at Wholesale less than Food at Retail ^{2/}				
1.....:	-.08	-.09	-.11	-.14	-.19
2.....:	-.15	-.19	-.22	-.28	-.38
5.....:	-.41	-.48	-.58	-.73	-1.00
10.....:	-.85	-1.00	-1.22	-1.58	-2.23
Percent decrease :					
1.....:	.08	.09	.11	.14	.18
2.....:	.15	.18	.22	.27	.36
5.....:	.38	.44	.52	.66	.85
10.....:	.73	.85	1.00	1.22	1.58

^{1/} Based on Marketing Costs of Food at Retail.

^{2/} These values are estimates of e_{UP} which is given in the equation $e_P = e_R + e_{UP}$.

If the marketing margin increases from 50 percent to 52 percent, the income elasticity of Food for Wholesale would be .22 below that for Food at Retail (table 12). If, on the other hand, the marketing margin declined 5 percent to 45 percent, the income elasticity of Food for Wholesale would be .52 greater than the income elasticity of Food at Retail. It is somewhat surprising to find that with a 20 percent increase in income as little as a 2-percentage-point change in the marketing margin will influence the elasticity of Food for Wholesale by as much as .3. It should also be noted that if per capita income increases less rapidly, the same changes in the marketing margin would increase the differences in the elasticities.

This table shows that the higher the marketing margin, the more influence will the same percentage point change in the margin have on the difference between the elasticities. Thus, with an initial marketing margin of 40 percent, a 2-percent increase in the marketing margin reduces the elasticity of Food for Wholesale by .19. If the initial margin was 60 percent, the reduction in Food for Wholesale elasticity would be .28. Thus, when the marketing margin is high, changes in the marketing margin have a much greater effect on Food for Wholesale.

The major point which emerges is that relatively small percentage point changes in the marketing margin cause rather great differences between the elasticities of Food at Retail and Food for Wholesale. This fact has important implications for nations undergoing development. If, for example, a nation succeeds in reducing Marketing Costs and hence the marketing margin

preciably, it should expect greatly increased demand for Food for Wholesale. On the other hand, if development in a nation results in a certain amount of reorganization in traditional marketing channels with increased uncertainty and turmoil in marketing, the increases in the marketing margin which would probably result would depress the demand for Food for Wholesale. 24/

Chapter VIII. -- THE INCOME ELASTICITY OF FOOD FOR WHOLESALE DURING DEVELOPMENT

One of the vital needs of a developing nation is to know how much food is required from its farmers, fishermen, and from imports. Shortages of food will result in inflation and a deceleration in the rate of economic growth. In this chapter the elements of analysis which have been developed in previous sections are brought together to estimate the elasticity of Food for Wholesale. Food for Wholesale is defined as the farm gate value of domestic farm products sold, plus the wharf value of the domestic fish catch, and the wharf value of imported foods. With knowledge of the elasticity of Food for Wholesale, estimates of national food needs can be made. The results obtained in this chapter and in the subsequent chapter on Supplier Food elasticities are the main objectives of this study.

The third equation in Chapter 3 showed that the elasticity of Food for Wholesale is influenced by the elasticity of Total Food, by changes in the ratio of Food at Retail to Total Food, and by changes in the marketing margin. In this chapter, the elasticity of Total Food is assumed given, and the elasticity of Food for Wholesale is assumed to be the dependent variable.

The elasticity of Total Food and of Food for Wholesale is the same if there is no change in the ratio of Food at Retail to Total Food, W_R , and if there is no change in the marketing margin, U_p . This fact is seen easily from the equation, for if there is no change in either W_R or in U_p the last two terms of the equation become zero.

Proceeding further, if changes occur in the ratio of Food at Retail to Total Food, but no changes occur in the marketing margin, only the last term U_p of the equation drops out. Data for changes in the ratio of Food at Retail to Total Food associated with changes in per capita income (the term W_R) were developed in Chapter 6, on the three Retail Food Paths. With the use of these food paths, and assuming values for the income elasticity of Total Food from .9 down to .4, income elasticities for Food for Wholesale were obtained (table 13). These elasticities for Food for Wholesale are the same as those given in Chapter 6 for Food at Retail. This is so because the two elasticities are the same when there is no change in the marketing margin.

A number of comments about the Food for Wholesale elasticities in this table are appropriate. First, due to the fact that the ratio of Food at Retail to Total Food increases throughout the table, even though slowly in high income ranges, the income elasticity of Food for Wholesale is always greater than that for Total Food. This is because it is likely that Food at Retail will always increase as a proportion of Total Food during development

24/ For additional analysis of aspects of changes in marketing margins see Dalrymple (17).

Table 13.--The income elasticities of Food for Wholesale on the three Retail Food Paths associated with specified elasticities of Total Food and specified income changes. The marketing margin is assumed not to change.

Per capita income change	: Retail Food Path <u>1/</u>	:The income elasticity of Food for Wholesale assuming the following income elasticities for Total Food					
		: .9 : .8 : .7 : .6 : .5 : .4					
\$50-\$200	: Low.....	1.69	1.59	1.49	1.39	1.29	1.19
	: Medium.....	1.40	1.30	1.20	1.10	1.00	.90
	: High.....	1.06	.96	.86	.76	.66	.56
\$200-\$500	: Low.....	1.46	1.36	1.26	1.16	1.06	.96
	: Medium.....	1.27	1.17	1.07	.97	.87	.77
	: High.....	1.10	1.00	.90	.80	.70	.60
\$500-\$1,000	: Low.....	1.48	1.38	1.28	1.18	1.08	.98
	: Medium.....	1.18	1.08	.98	.88	.78	.68
	: High.....	.98	.88	.78	.68	.58	.48

1/ For explanation of the meaning of the Retail Food Paths, see Chapter 5.

except under very extraordinary conditions such as war or severe economic depression. Thus, the only way it is likely for the elasticity of Food for Wholesale to become less than that for Total Food during development is if changes in the marketing margin counteract this effect. (see below).

Secondly, the generally high level of the elasticities throughout the table imply the necessity for rapid agricultural development or the importation of major quantities of food as low-income countries develop. It should be noted, for example, that many of the elasticities in this table are above unity. This means that the demand for Food for Wholesale appears likely to grow about as rapidly as per capita income, particularly during the early phases of development. It is only in the middle and high income ranges of the High Retail Food Path that the elasticity of Food for Wholesale drops toward .5. It is also of interest that even if the conservative elasticity of .5 for Total Food is employed, it is unlikely that the elasticity of Food for Wholesale will be below .6 assuming, of course, no change in the marketing margin.

Now, if the marketing margin is permitted to vary, in addition to increases in the ratio of Food at Retail to Total Food, the combined effect of all the variables may be examined. Previously, it was found that an increase in the marketing margin generally results in the reduction in the elasticity of Food for Wholesale, while a decrease in the marketing margin results in an increase in the elasticity of Food for Wholesale.

An illustration of the magnitude of the effect of specified changes in the marketing margin was worked out (table 14). To provide the most conservative elasticities for Food for Wholesale, the lowest reasonable value for the

Table 14.--Income elasticities of Food for Wholesale on the three Retail Food Paths, assuming specified changes in income and in the marketing margin when the income elasticity of Total Food is .4

		Food for Wholesale elasticity				
er capita income ncrease	Retail Food Path	With a 5 percent :		With a 5 percent		
		decrease in the :		increase in the		
		marketing margin :		marketing margin		
		60 to 55: 40 to 35:	the market-	40 to 45: 60 to 65		
		percent :	percent :	ing margin :	percent :	percent
(1)	(2)	(3)	(4)	(5)	(6)	(7)
50-\$200	Low.....	1.27	1.25	1.19	1.13	1.09
	Medium...	.98	.96	.90	.84	.80
	High.....	.64	.62	.56	.50	.46
200-\$500	Low.....	1.12	1.08	.99	.90	.85
	Medium...	.90	.86	.77	.68	.63
	High.....	.73	.69	.60	.51	.46
500-\$1,000	Low.....	1.15	1.10	.98	.86	.79
	Medium...	.85	.80	.68	.56	.49
	High.....	.65	.60	.48	.36	.29

elasticity of Total Food of .4 was assumed in this illustration. The elasticity of Food at Wholesale with no change in the marketing margin is shown in column 5, table 14.

However, decreases in the marketing margin result in higher elasticities (col. 3 and 4, table 14). Given the changes in income specified, a 5-percent decrease in the marketing margin increases the elasticity of Food for Wholesale from .06 to .17. If the marketing margin decreases from 40 percent to 35 percent in the \$50 to \$200 per capita income range, the elasticity of Food for Wholesale is .06 greater than if there had been no change in the marketing margin: i.e., the elasticity of 1.19 is increased to 1.25. In this income range, if the marketing margin decreases from 60 percent to 55 percent, the increase in the elasticity is slightly greater, .08. In the medium per capita income range, a 5-percent decrease in the marketing margin increases the Food for Wholesale elasticity by approximately .10, depending upon the margin from which the change began. In the high per capita income range the effect is greater.

On the other hand, a 5-percent increase in the marketing margin for specified income changes shows that the elasticity of Food for Wholesale would be reduced from .06 to .19, depending upon the levels of the variables. For example, an increase in the marketing margin from 40 to 45 percent, while per capita income is increasing from \$50 to \$200 on the Low Retail Food Path, would decrease the Food for Wholesale elasticity from 1.19 to 1.13 and so forth.

The data in table 14 indicate that if the change in the marketing margin were greater than 5 percent, the influence on the elasticity of Food for Wholesale sale would be greater and vice versa.

It is not possible to say whether there is likely to be a reduction in the marketing margin or an increase in the marketing margin during the early phases of development. Certainly, considerable reduction in the marketing margin may be expected in some regions and for some crops where very inefficient marketing systems are used. In other situations, high costs of transportation may be replaced by more packaging and processing, leaving the marketing margin about the same. Major increases in the marketing margin do not appear likely until the later stages of development when consumers begin to demand greatly increased amounts of services with their foods, except, of course, in conditions of war or economic turmoil. Thus, in conclusion, it appears that Food for Wholesale elasticities will probably be at least as great as the elasticities of Food at Retail. If major improvements in the marketing system are achieved during development and they decrease the marketing margin, Food for Wholesale elasticities will be greater than the elasticities of Food at Retail. The data in table 14 suggest that the magnitude of the effect of the reduction in the marketing margin may be enough to increase the Food for Wholesale elasticity .1 or more above the Food at Retail elasticity.

Chapter IX. -- THE INCOME ELASTICITY OF SUPPLIER FOOD DURING DEVELOPMENT

In the preceding chapter estimates were obtained of the elasticity of the value of Food for Wholesale, that is, food needed in the marketing channels from farmers, fishermen, and from imports. In this chapter the elasticity of the value of Supplier Food will be analyzed. Supplier Food is defined as the sum of Food for Wholesale and Home-produced Food. Thus, the focus here is on the net national production of food including fish plus imports. If imports of food and the domestic fish catch are of minor importance or certain magnitudes can be assumed for these sources of foods, the total required net farm production of food may be estimated. Thus, Supplier Food is considered to be the dependent variable. With knowledge of Supplier Food requirements the resources needed for the agricultural sector may be better gauged.

The development of the mathematical relations between the elasticities of food at the different levels of food measurement in Chapter 3 showed that if an additional term is added to the equation used in the preceding chapter estimates of the income elasticity of Supplier Food would be obtained (Appendix 2). This additional term has a negative value and contains the variable showing the ratio of Food for Wholesale to Supplier Food (T_p). If there is no change in the ratio of Food for Wholesale to Supplier Food, the elasticity of food at these two levels is the same. No change in this ratio would mean that Home-produced Food was increasing at the same rate as Food for Wholesale during development. This is unlikely, except possibly in very poor countries before much economic development occurs; for as income increases and urbanization occurs, the proportion of Home-produced Food must always decline. Also, any change in the marketing margin would change the ratio of Food for Wholesale to Supplier Food.

The Ratio of Food for Wholesale to Supplier Food (T_P),
During Development

Before one may estimate the elasticity of Supplier Food, data on the ratio Food for Wholesale to Supplier Food during development is required. All the other data needed in the equation have already been obtained in earlier chapters. From preceding chapters it is clear that the value of Food for Wholesale depends upon the marketing margin as well as other variables. In the calculations which follow, the marketing margin was varied from 35 percent to 65 percent on each of the three Retail Food Paths (table 15).

Table 15.--The ratio of Food for Wholesale to Supplier Food (T_P) on the three Retail Food Paths with specified marketing margins ^{1/}

Retail Food Path	Marketing margin (U _m)	Per capita income				
		\$50	\$200	\$500	\$1,000	
	Percent	Percent	Percent	Percent	Percent	
Low	35	6.7	21.8	39.4	66.1	
	40	6.2	20.5	37.5	64.3	
	45	5.7	19.1	35.5	62.3	
	50	5.4	17.6	33.3	60.1	
	55	4.8	16.2	31.0	57.4	
	60	4.3	14.6	28.6	54.5	
	65	3.7	13.0	25.9	51.2	
Medium	35	17.8	39.4	60.3	78.6	
	40	16.7	37.5	58.3	77.3	
	45	15.5	35.5	56.2	75.7	
	50	14.4	33.3	54.0	73.8	
	55	13.0	31.0	51.2	71.8	
	60	11.8	28.6	48.3	69.4	
	65	10.4	25.9	45.0	66.5	
High	35	49.4	66.1	85.4	92.5	
	40	47.4	64.3	84.4	91.9	
	45	45.2	62.3	83.2	91.3	
	50	42.8	60.0	82.2	90.6	
	55	40.3	57.4	80.2	89.5	
	60	37.5	54.5	78.3	88.4	
	65	34.3	51.2	75.9	86.9	

^{1/} This ratio can be obtained from the following equation:

$$T_P = \frac{V_P}{V_O}, \quad V_P = (1 - U_m) V_R, \quad V_O = V_P + V_S. \quad V_S \text{ and } V_R \text{ were obtained from}$$

Table 10. For methodology, see Appendix 2.

The ratio of Food for Wholesale to Supplier Food shown in table 15 indicates the proportion of total national food production and imports which enter marketing channels, i.e., the proportion of food which leaves the farm gate and wharf. The remaining portion of total national food is home produced and home consumed. The way the ratio of Food for Wholesale to Supplier Food changes as income rises is seen more clearly in figure 9.

The effect of different marketing margins is also shown in the figure. The solid lines for the three Retail Food Paths were drawn assuming a constant 50 percent marketing margin. The dotted line on either side of the Medium Retail Food Path shows the effect of a marketing margin 10 percent higher or lower. The figure also indicates that the Retail Food Paths generally have much more influence on the ratio of Food for Wholesale to Supplier Food than the marketing margin. The Retail Food Paths cause great differences in the T ratio as income rises.

Critical examination of these three food paths suggests that at the low-income end of the figure, the Low and Medium Retail Food Paths are more realistic. However, for higher incomes, the High Retail Food Path appears more reasonable. If these conclusions are substantiated by empirical studies, an even more rapid decline in the ratio of Home-produced Food to Total Food at low per capita income levels would occur than was posited in setting up these Retail Food Paths. A more rapid decline in the ratio of Home-produced Food to Total Food would increase the income elasticities of Food at Retail and Food for Wholesale to even higher levels than those given in earlier sections of this study.

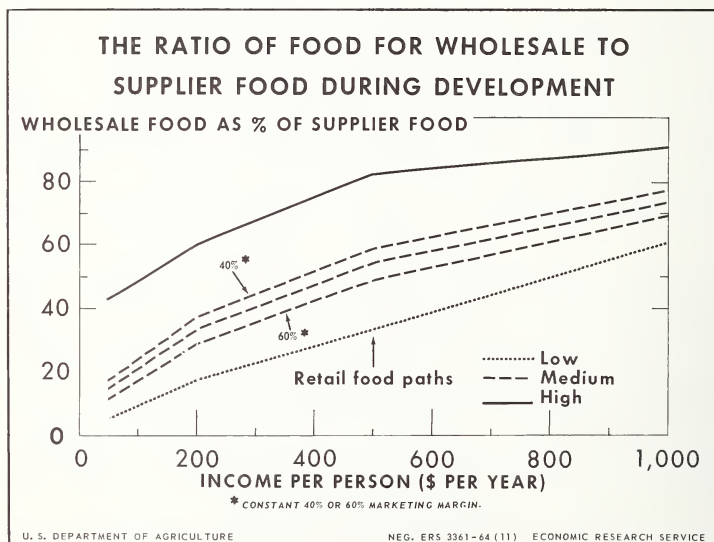


Figure 9

The ratio of Home-produced Food to Supplier Food may be observed by reading the percentage scale at the right side of the figure. Both ratios can be given in the same figure because $T_p = 1 - T_s$, that is the ratio of Supplier Food to Food for Wholesale, plus the ratio of Home-produced Food to Food for Wholesale, equals unity.

Per capita values of Food for Wholesale and Supplier Food under various assumptions are given in table 16. For this calculation the initial levels of food consumption, the elasticity of Total Food, and two different marketing margins were specified. These data illustrate the growth in the per capita value of food and marketing services which may occur with development.

The Elasticity of Supplier Food. The elasticity of Supplier Food was estimated by using the last equation in Chapter 3. ^{25/} First, values for the three last terms of the equation (e_{W_R} , e_{U_p} , and e_{T_p}) will be given under specified assumptions. Then the sum of the three terms will be considered. Finally, the elasticity of Supplier Food will be presented with different assumptions of the elasticity of Total Food.

The three terms in the equation influencing the elasticity of Supplier Food are: Changes in the ratio of Food at Retail to Total Food (W_R), changes in the marketing margin (U_p), and changes in the ratio of Food for Wholesale to Supplier Food (T_p). For changes in the ratio of Food at Retail to Total Food the three Retail Food Paths were used. To illustrate the magnitude of the effect of changes in the marketing margin, this margin was reduced and increased 5 percentage points from an initial level of 40 percent and from an initial level of 60 percent. Two initial levels for the marketing margin were required as it was found that the initial level of the marketing margin has some influence. Changes in the ratio of Food for Wholesale to Supplier Food are determined jointly by the changes in the marketing margin and the changes in the Retail Food Paths.

Examination of the values obtained in table 17 for the three last terms of the equation shows that, changes in the ratio of Food at Retail to Total Food are generally much more important than changes in the marketing margin. However, it is of interest to note that in the high income range on the Medium and High Retail Food Paths, the influence of a change in the marketing margin comes relatively much more important. On the High Retail Food Path at the high income level, changes in the marketing margin have a greater influence on a change in the ratio of Food at Retail to Total Food. For example, in the bottom line of the first half of the table at the high income level an increase of 5 percentage points in the marketing margin decreases the elasticity .9 while at the same time the effect of the change in the ratio of Food at Retail to Total Food is only .08. The major explanation for this low value .08 is that the ratio of Food at Retail to Total Food is changing only very slowly at this income level and, hence, this small ratio change has little influence on the elasticity of Supplier Food.

^{25/} One might use a simpler relation, but it is more instructive to observe the relative importance of the different variables by using the more complex equation. (See equations A10-A14 in Appendix 2.)

Table 16.--Per capita consumption of Food for Wholesale and Supplier Food and Marketing Costs on the three Retail Food Paths associated with changes in income, assuming an income elasticity of Total Food of .8, .7, and .5, and a market margin of 60 percent 1/

Income elasticity of Total Food	Retail Food Path	Food Measure on Marketing Cost	Income per capita			
			\$50	\$200	\$500	\$1,000
.8	Low	Marketing Costs (V_M)	2.4	19	66	173
		Food for Wholesale (V_P)	1.6	13	44	115
		Supplier Food (V_0)	33	87	155	211
	Medium	Marketing Cost (V_M)	5.4	32	93	196
		Food for Wholesale (V_P)	3.6	21	62	130
		Supplier Food (V_0)	30	74	122	188
	High	Marketing Cost (V_M)	12.6	48	119	219
		Food for Wholesale (V_P)	8.4	32	80	146
		Supplier Food (V_0)	22	58	102	165
.7	Low	Marketing Costs (V_M)	2.4	17	52	128
		Food for Wholesale (V_P)	1.6	11	35	86
		Supplier Food (V_0)	33	76	122	157
	Medium	Marketing Cost (V_M)	5.4	28	74	145
		Food for Wholesale (V_P)	3.6	18	49	97
		Supplier Food (V_0)	30	64	101	140
	High	Marketing Cost (V_M)	12.6	41	95	163
		Food for Wholesale (V_P)	3.6	18	49	97
		Supplier Food (V_0)	22	51	80	122
.5	Low	Marketing Costs (V_M)	2.4	13	33	71
		Food for Wholesale (V_P)	1.6	8	22	47
		Supplier Food (V_0)	33	57	77	86
	Medium	Marketing Cost (V_M)	5.4	21	47	80
		Food for Wholesale (V_P)	3.6	14	31	53
		Supplier Food (V_0)	30	49	64	77
	High	Marketing Cost (V_M)	12.6	31	60	89
		Food for Wholesale (V_P)	8.4	21	40	60
		Supplier Food (V_0)	22	39	51	68

1/ Calculated from data for $V_R + V_S$ in table 10.

V_M = (marketing margin) (V_R). $V_P = V_R - V_M$. $V_0 = V_P + V_S$.

Table 17.--The relative influence of changes in Home-produced Food, the marketing margin, and the ratio of Food for Wholesale to Supplier Food on the income elasticity of Supplier Food under specified assumption 1/

		Change in income per capita								
		\$50-200			\$200-500			\$500-1,000		
Marketing margin	Retail Food Path	e_W	e_U	e_T	e_W	e_U	e_T	e_W	e_U	e_T
		R	P	P	R	P	P	R	P	P
<u>A. Marketing margin initially at 60 percent</u>										
Decrease from 60 percent to 5 percent:	Low	.79	.08	-.96	.56	.13	-.82	.58	.17	-1.00
	Medium	.50	.08	-.70	.37	.13	-.64	.28	.17	-.57
	High	.16	.08	-.31	.20	.13	-.42	.08	.17	-.19
Constant 0 percent:	Low	.79	--	-.88	.56	--	-.73	.58	--	-.93
	Medium	.50	--	-.64	.37	--	-.57	.28	--	-.52
	High	.16	--	-.27	.20	--	-.40	.08	--	-.17
Decrease from 60 percent to 5 percent:	Low	.79	-.10	-.80	.57	-.15	-.62	.58	-.19	-.84
	Medium	.50	-.10	-.57	.37	-.15	-.49	.28	-.19	-.46
	High	.16	-.10	-.22	.20	-.15	-.36	.08	-.19	-.15
<u>B. Marketing margin initially at 40 percent</u>										
Decrease from 40 percent to 5 percent:	Low	.79	.06	-.91	.56	.09	-.71	.58	.12	-.82
	Medium	.50	.06	-.62	.37	.09	-.52	.28	.12	-.43
	High	.16	.06	-.24	.20	.09	-.31	.08	.12	-.13
Constant 0 percent:	Low	.79	--	-.86	.56	--	-.66	.58	--	-.78
	Medium	.50	--	-.58	.37	--	-.48	.28	--	-.41
	High	.16	--	-.22	.20	--	-.30	.08	--	-.12
Decrease from 40 percent to 5 percent:	Low	.79	-.06	-.81	.56	-.09	-.60	.58	-.13	-.73
	Medium	.50	-.06	-.54	.37	-.09	-.44	.28	-.13	-.38
	High	.16	-.06	-.20	.20	-.09	-.28	.08	-.13	-.11

1/ See Appendix 2 for the mathematical definitions of e_{WR} , e_{UP} and e_{TP} .

The difference between the income elasticity of Total Food and the income elasticity of Supplier Food was obtained from the sum of the three terms presented in table 17. These sums are given in table 18. The table is separated into two parts, one with a marketing margin initially at 60 percent, and the other with the margin initially at 40 percent. If marketing margins of approximately 40 percent are realistic, in the lower two income ranges Supplier Food will be about .05 to .15 less than Total Food under the assumptions of the study. Only in the high income range in a few circumstances does the elasticity of Supplier Food become .2, or more, less than Total Food.

Table 18.--The difference between the elasticity of Supplier Food (e_0) and the elasticity of Total Food (e_A) under specified assumptions ^{1/}

Marketing	:	Retail Food	:	Per capita income change		
Margin	:	Path	:	\$50-\$200	\$200-\$500	\$500-\$1,000
<hr/>						
A. Marketing margin initially at 60 percent						
Decrease from	:	Low.....	:	-.09	-.13	-.25
60 percent to 55:	:	Medium.....	:	-.12	-.14	-.12
	:	High.....	:	-.07	-.09	+.06
	:		:			
Constant	:	Low.....	:	-.09	-.17	-.35
60 percent	:	Medium.....	:	-.14	-.20	-.24
	:	High.....	:	-.11	-.20	-.09
	:		:			
Increase from	:	Low.....	:	-.11	-.21	-.45
60 percent to 65:	:	Medium.....	:	-.17	-.27	-.37
	:	High.....	:	-.16	-.31	-.26
	:		:			
<hr/>						
B. Marketing margin initially at 40 percent						
Decrease from	:	Low.....	:	-.06	-.06	-.12
40 percent to 35:	:	Medium.....	:	-.06	-.06	-.03
	:	High.....	:	-.02	-.02	+.07
	:		:			
Constant	:	Low.....	:	-.07	-.10	-.20
40 percent	:	Medium.....	:	-.08	-.11	-.13
	:	High.....	:	-.06	-.10	-.04
	:		:			
Increase from	:	Low.....	:	-.08	-.13	-.28
40 percent to 45:	:	Medium.....	:	-.10	-.16	-.23
	:	High.....	:	-.10	-.17	-.16
	:		:			

^{1/} The values in the table equal $e_0 - e_A$ and are the sum of $e_{WR} + e_{UP} + e_{TP}$ from table 17.

If a marketing margin in the neighborhood of 60 percent is more realistic the difference between the income elasticity of Supplier Food and Total Food

somewhat greater. Considering the low per capita income range first, the elasticity of Supplier Food will be from .07 to .17 less than the elasticity of Total Food. In the middle per capita income range, the elasticity of Supplier Food on the High Retail Food Path with an increasing marketing margin may be as much as .31 less than that for Total Food.

In the high income range the difference may be even greater. The Retail Food Path followed greatly influences the difference between these two elasticities in this income range. Reference to table 6 and figure 7 helps explain why these great differences in elasticities occur in the high income range. For example, on the High Retail Food Path in the high income range, little change is occurring in either the ratio of Food at Retail to Total Food or consequently in the ratio of Food for Wholesale to Supplier Food. In contrast, major changes occur in both variables on the Low Retail Food Path at this income level.

Table 18 shows that the differences in marketing margins generally yield no more than a .1 difference in the value of elasticity except in the high income range.

The income elasticity for Supplier Food may now be given under the various assumptions (table 19). The table is in two parts, the first (part A) assumes an initial marketing margin of 60 percent in all cases, the second (part B) assumes an initial marketing margin of 40 percent in all cases. Part A can be used to illustrate the income elasticities of Supplier Food indicated by this study. In all cases the income elasticities for Supplier Food are lower than those in part B which has a lower marketing margin. Thus, should the marketing margin be found to be less than approximately 60 percent, the elasticities of Supplier Food will be greater than those given in part A of the table.

Part A of table 19 indicates that the income elasticity of Total Food is the dominant influence on the income elasticity of Supplier Food. An income elasticity for Total Food of .9 keeps all but one of the Supplier Food elasticities above .5, while a .4 elasticity for Total Food lets a number of elasticities for Supplier Food drop below .2.

In the columns for the low and medium per capita income ranges, if the income elasticity of Total Food is .9 the elasticity of Supplier Food ranges from .83 to .59. If the Total Food elasticity is .7 the Supplier Food elasticity ranges from .63 to .39, while with the income elasticity for Total Food at .4, the range of the Supplier Food elasticity is from .33 to .09.

The elasticity of Supplier Food for the high per capita income range is influenced a great deal by the Retail Food Path followed and changes in the marketing margin. It will be remembered that in a previous chapter, the Medium and High Retail Food Paths were judged to be more realistic at the high income level. If a Total Food elasticity of .7 is assumed on the Medium Retail Food Path, the income elasticity of Supplier Food would be .46, while on the High Retail Food Path, the elasticity would be .61. Changes of 5 percentage points in the marketing margin at the high income level will increase or decrease the elasticity of Supplier Food by approximately .1. Similar statements can be made assuming different values for the elasticity of Total Food.

Table 19.--The income elasticity of Supplier Food under specified assumptions

A. Marketing margin initially at 60 percent						
Income elasticity of Total Food	Marketing margin	Retail Food Path	Per capita income change			
			\$50-200	\$200-500	\$500-1,000	
.9	<u>Decrease</u>					
	60 percent	Low	.81	.77	.65	
	to	Medium	.78	.76	.78	
	55 percent	High	.83	.81	.96	
	<u>Constant</u>	Low	.81	.73	.56	
	At	Medium	.76	.70	.66	
	60 percent	High	.79	.70	.81	
	<u>Increase</u>					
	from 60	Low	.79	.69	.45	
	percent to	Medium	.73	.63	.53	
	65 percent	High	.74	.59	.64	
.7	<u>Decrease</u>					
	from 60	Low	.61	.57	.45	
	percent to	Medium	.58	.56	.58	
	55 percent	High	.63	.61	.76	
	<u>Constant</u>	Low	.61	.53	.35	
	At	Medium	.56	.50	.46	
	60 percent	High	.59	.50	.61	
	<u>Increase</u>					
	from 60	Low	.59	.49	.25	
	percent to	Medium	.53	.43	.33	
	65 percent	High	.54	.39	.44	
.4	<u>Decrease</u>					
	from 60	Low	.31	.27	.15	
	percent to	Medium	.28	.26	.28	
	55 percent	High	.33	.31	.46	
	<u>Constant</u>	Low	.31	.23	.05	
	At	Medium	.26	.20	.16	
	60 percent	High	.29	.20	.31	
	<u>Increase</u>					
	from 60	Low	.29	.19	-.05	
	percent to	Medium	.23	.13	.03	
	65 percent	High	.24	.09	.14	

Continued

Table 19.--The income elasticity of Supplier Food under specified assumptions -Continued

B. Marketing margin initially at 40 percent						
Income elasticity of Total Food	Marketing margin	Retail Food Path	Per capita income change			
			\$50-200	\$200-500	\$500-1,000	
.9						
	<u>Decrease</u>					
	40 percent	Low	.84	.84	.78	
	to	Medium	.84	.84	.87	
	35 percent	High	.88	.88	.97	
	<u>Constant</u>	Low	.83	.80	.70	
	At	Medium	.82	.79	.77	
	40 percent	High	.84	.80	.86	
	<u>Increase</u>					
	40 percent	Low	.82	.77	.62	
	to	Medium	.80	.74	.67	
	45 percent	High	.80	.73	.72	
.7						
	<u>Decrease</u>					
	40 percent	Low	.64	.64	.58	
	to	Medium	.64	.64	.67	
	35 percent	High	.68	.68	.77	
	<u>Constant</u>	Low	.63	.60	.50	
	At	Medium	.62	.59	.58	
	40 percent	High	.64	.60	.66	
	<u>Increase</u>					
	40 percent	Low	.62	.57	.42	
	to	Medium	.60	.54	.47	
	45 percent	High	.60	.53	.52	
.4						
	<u>Decrease</u>					
	40 percent	Low	.34	.34	.28	
	to	Medium	.34	.34	.37	
	35 percent	High	.38	.38	.47	
	<u>Constant</u>	Low	.33	.30	.20	
	At	Medium	.32	.29	.27	
	40 percent	High	.34	.30	.36	
	<u>Increase</u>					
	40 percent	Low	.32	.27	.12	
	to	Medium	.30	.24	.17	
	45 percent	High	.30	.23	.22	

A comparison of the elasticities of Food for Wholesale obtained in the previous chapter with the Supplier Food elasticities in this chapter indicate that the Food for Wholesale elasticities are surprisingly high, in many cases running above 1.0. Also, the Food for Wholesale elasticities were always found to be greater than the income elasticity of Total Food. The elasticities of Supplier Food in contrast are almost all less than the elasticity of Total Food, usually by about .1 or .2. This is due to the gradual increase in overall Marketing Costs and the decrease in Home-produced Food.

The contrast between these elasticities can be seen in figure 10. In this example, an elasticity for Total Food of .7 is employed with the initial

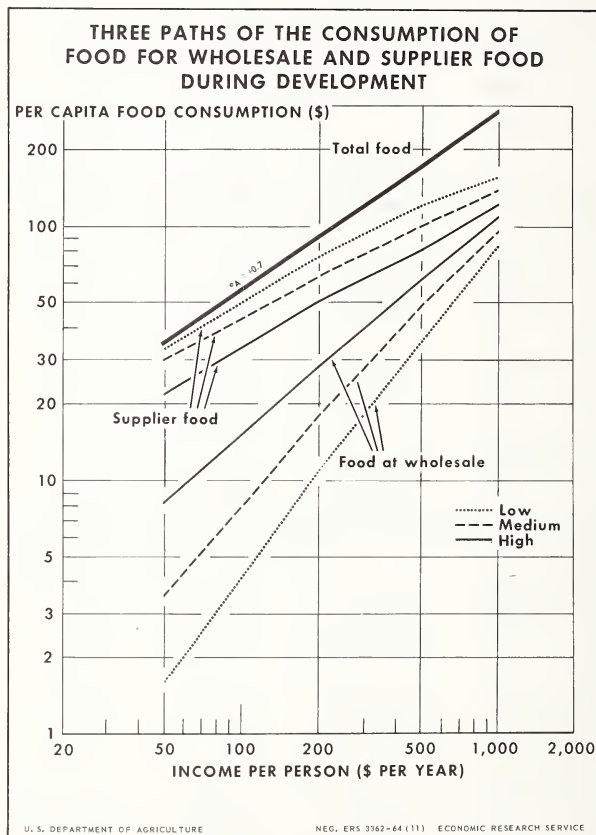


Figure 10

level of food consumption at \$35 when per capita income is \$50. A 60 percent marketing margin is assumed throughout. It is seen that the value of Food for Wholesale per capita rises relatively rapidly, while at the same time Supplier Food decreases proportionately to Total Food. Home-produced Food becomes relatively less important and Marketing Costs take a larger and larger share of the value of Total Food. The difference between the Supplier Food Path and the Total Food Path on this figure represents Marketing Costs (Appendix 2). It is easily seen that at higher incomes this difference becomes much larger. Marketing Costs become greater proportionately. For example, on the Medium Tail Food Path when per capita income is \$50, only 15 percent of Total Food are Marketing Costs, while at the \$1,000 per capita income level, Marketing Costs represent 51 percent of Total Food.

Some of the general conclusions from this chapter can be summarized as follows. First, this analysis indicates that the elasticity of Supplier Food is likely to be somewhat less perhaps by .1 or .2 than the elasticity of Total Food during development. This is because Home-produced Food is being gradually replaced by Food for Wholesale, which has a Marketing Costs component added to it before it becomes Food at Retail.

Hence, the demand for agricultural resources will generally not grow quite as rapidly as the growth in the value of Total Food per capita. In spite of this, if the elasticity of Total Food remains high, the elasticity of Supplier Food is considerable. For example, the results of this study showed that with a Total Food elasticity of .7 up to the \$500 per capita income level, the range of the income elasticities for Supplier Food is from .3 to .39, assuming a 60 percent marketing margin. 26/

A finding of particular interest is that when per capita incomes are high, changes in the marketing margin have much more influence on the elasticity of Supplier Food than at lower incomes.

Chapter X. -- EXAMPLES OF RATES OF INCREASE IN FOOD REQUIREMENTS DURING DEVELOPMENT

The focus of this report has been on developing methods for obtaining estimates of the income elasticity of the value of food per capita at different levels of food measurement. In this chapter some of the rates of growth of food requirements implied by the elasticities obtained in preceding chapters are examined. Probable rates of population growth and increases in per capita income are included.

In planning for rapid economic growth, estimates of the rate at which Food for Wholesale and Supplier Food must grow to maintain economic growth are highly desirable. These rates may be estimated using the appropriate income elasticities and Ohkawa's equation, $d = p + gn$, discussed in Chapter 1. The last term of this equation shows the rate of increase in food above the

26/ For recent empirical estimates of the income elasticity of the farm value of all food for a large number of countries, see Agricultural Commodities...Projections for 1970 (20).

rate of population growth, which is required to meet national food requirements. Thus, if a nation is expected to have a 2-percent increase in per capita income, and if the income elasticity of Food for Wholesale is .7, Food for Wholesale would have to increase at a rate which is 1.4 percent faster than the rate of population growth (table 20). To take another example, if the elasticity of Supplier Food were .2, with the same per capita income growth, the rate of increase in Supplier Food requirements would have to be .4 percent faster than the rate of population growth. In this case, if population were growing at 2.5 percent per year, the rate of increase in Supplier Food would need to be 2.9 percent per year.

Table 20.--The effect of increases in per capita income on the rate of growth of consumption ^{1/}

Annual rate of growth in per capita income (g)	Income elasticity of demand for food (n)			
	1.5	1.0	.7	.2
Percent per year				
1.....	1.5	1.0	.7	.2
2.....	3.0	2.0	1.4	.4
3.....	4.5	3.0	2.1	.6

^{1/} The table shows the rate, above the population growth rate, at which food consumption will increase under specified conditions. The values in the table are for the income elasticity of food multiplied by the per capita income growth rate (gn).

Example of rates of growth in food requirements, (the value for "d" in Ohkawa's equation) are given in table 21. In this table per capita income growth has values of 1, 2, and 3 percent, the population growth rate varies from 1 to 3 percent. The income elasticity of food was given the values of 1.5, 1.0, .7, and .2 in this table.

If we consider Food at Retail first, it will be remembered that many of the income elasticities for Retail Food were 1.0 or above, particularly at low per capita incomes. If the elasticity of 1.0 is used, the highest rate of growth in Food at Retail would be 6.0 percent per year when both income and population are growing at 3 percent per year (table 21). If per capita income should grow at only 2 percent per year, the same population growth rate would require a 5 percent annual increase in Food at Retail. At lower rates of growth, say with the population increasing at 2 percent per year and per capita income rising at 1 percent per year, the rate of growth in Food at Retail would still be 3 percent per year--three times as fast as per capita income was growing.

This study showed that when the elasticity of Total Food was .9, Supplier Food elasticities ranged around .7. Using this elasticity for Supplier Food in table 21, we see that the rate of growth in Supplier Food requirements may be as high as 5.1 percent per year. However, if population grows at 2 percent

Table 21.--The annual rate of growth in national food requirements under different rates of population and income growth, and income elasticities for food ^{1/}

Annual rate of population growth	Annual rate of growth in per capita income											
	1				2				3			
	Elasticity of food				Elasticity of food				Elasticity of food			
	1.5	1.0	.7	.2	1.5	1.0	.7	.2	1.5	1.0	.7	.2
Percent	Percent				Percent				Percent			
1.0.....	2.5	2.0	1.7	1.2	4.0	3.0	2.4	1.4	5.5	4.0	3.1	1.6
1.5.....	3.0	2.5	2.2	1.7	4.5	3.5	2.9	1.9	6.0	4.5	3.6	2.1
2.0.....	3.0	3.0	2.7	2.2	5.0	4.0	3.4	2.4	6.5	5.0	4.1	2.6
2.5.....	4.0	3.5	3.2	2.7	5.5	4.5	3.9	2.9	7.0	5.5	4.6	3.1
3.0.....	4.5	4.0	3.7	3.2	6.0	5.0	4.4	3.4	7.5	6.0	5.1	3.6

^{1/} The table gives the value of "d" in Ohkawa's equation $d = p + gn$.

At 1 percent per capita income, Supplier Food requirements would increase at a more modest rate of 2.7 percent per year. In high income countries, where the income elasticity of Supplier Food is likely to be about .2, the highest growth rate of Supplier Food requirements is 3.6 percent per year. The rate for a 2-percent increase in both population and per capita income is 4 percent per year. It is easily seen from the data in table 21 that the combination of high population growth and high income elasticity for food make the rate of growth in food requirements much greater in the low-income countries than in the higher income countries. The high rates of growth in food requirements in low-income countries due to these two factors are increased even more if the countries succeed in rapidly increasing per capita income.

The findings of this study can perhaps be illustrated by focusing on likely changes in the rate of growth in Food for Wholesale requirements as development occurs (table 22). Consider first the situation in traditional societies where over many centuries there has been essentially no growth in population and no growth in per capita income. Under these circumstances, obviously, there has been little need for any increase in Food for Wholesale. The required rate of growth in Food for Wholesale has therefore been close to zero.

Many traditional societies have had some population growth from time to time often with little change in per capita income. If population grows at 1 percent per year and there is no increase in per capita income, Food for Wholesale must increase at approximately 1 percent per year assuming no other changes in the society (column 4, table 22).

Now consider the rate of growth in Food for Wholesale after economic development has commenced. We know from nations such as India and the Philippines that the population growth rate often rises as high as 2.5 percent or more. Such countries often attempt in their development plans to achieve

Table 22.--The rate of growth in Food for Wholesale requirements during economic development under specified conditions 1/

		Income Per Capita <u>2/</u>				
		Constant:	Constant:	Increasing:	Increasing:	Increasing:
		at \$50	at \$50	from	from	from
				\$50-200	\$200-500	\$500-1,000
		No	1%	2.5%	2.0%	1.5%
Elasticity of Total Food	Retail	popula-	popula-	popula-	popula-	popula-
	Food	tion	tion	tion	tion	tion
	Path	growth	growth	growth	growth	growth
		Constant:	Constant:	Marketing:	Constant:	Marketing:
		marketing:	marketing:	margin	marketing:	margin
		margin	margin	decreases	margin at:	increase
				60 to 55%	55%	55 to 60
(1)	(2)	(3)	(4)	(5)	(6)	(7)
-Percent-						
.9	Low.....	0	1.0	6.0	4.9	4.1
	Medium....	0	1.0	5.5	4.5	3.5
	High.....	0	1.0	4.8	4.2	3.1
.7	Low.....	0	1.0	5.6	4.5	3.7
	Medium....	0	1.0	<u>5.1</u>	<u>4.1</u>	<u>3.1</u>
	High.....	0	1.0	4.4	3.8	2.7
.4	Low.....	0	1.0	5.0	4.0	3.1
	Medium....	0	1.0	4.5	3.5	2.5
	High.....	0	1.0	3.8	3.2	2.1

1/ The table gives the value of "d" for Food for Wholesale in Ohkawa's equation $d = p + gn$.

2/ Per capita income is assumed to grow at 2 percent per year.

rates of per capita income growth of 3 percent which, however, are not often achieved. We will assume that income per capita grows at 2 percent per year. The income elasticity of Total Food will be assumed conservatively as .7 in this example. We will also assume that as per capita income increases from \$50 to \$200 the marketing margin decreases from 60 percent to 55 percent. Under these circumstances on the Medium Retail Food Path the rate of growth in Food for Wholesale would be 5.1 percent per year (col.5, table 22). Half of this high rate of growth in Food for Wholesale is due to the 2 percent growth rate in per capita income.

Studies at higher per capita income levels have shown that the rate of population growth generally decreases as nations continue to grow. We will assume that at per capita incomes of between \$200 and \$500 population growth decreases to 2 percent per year. The marketing margin is assumed in this case to remain at 55 percent and the rate of per capita income growth to remain at

percent. With these assumptions on the Medium Retail Food Path and with a elasticity for Total Food, the rate of growth in Food for Wholesale drops 4.1 percent (col. 6, table 22).

At still higher per capita income levels--between \$500 and \$1,000--and with the population growth rate set still lower at 1.5 percent, but including increase in the marketing margin from 55 to 60 percent, the average rate of growth in Food for Wholesale would be 3.1 percent.

Some of these changes in the rate of growth in Food for Wholesale are given in figure 11. The solid line shows the dramatic changes during economic development in the rate of growth in Food for Wholesale discussed above. The major conclusion shown here is that Food for Wholesale requirements can be expected to grow most rapidly in the early stages of economic growth. This is the time when population is likely to be growing most rapidly, and it is also a time when high rates of growth in per capita income will cause proportionately rapid shifts from Home-produced Food to Food for Wholesale.

Two modifications are also illustrated in figure 11. The dotted line shows the effect of assuming a declining income elasticity for Total Food. In this case, a Total Food elasticity of .8 was assumed in the \$50 to \$200 per capita income range, while in the higher per capita income range a Total Food elasticity of .6 was assumed. The figure shows that if all other conditions are the same

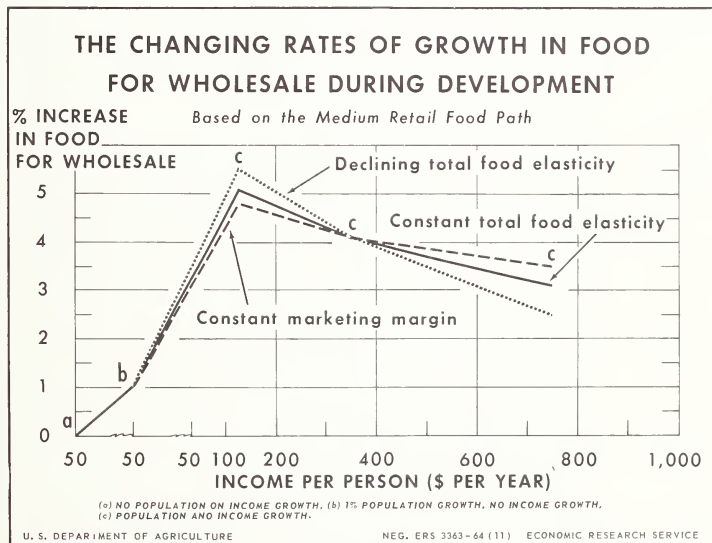


Figure 11

as discussed previously, a declining income elasticity of Total Food causes even greater changes in the rate of growth in Food for Wholesale requirements.

A third set of conditions was tested in figure 11 by examining the effect of no change in the marketing margin (dashed line). If the marketing margin remains the same throughout the process of development, the rate of growth of Food for Wholesale would not rise quite so high and it would not decline as rapidly as under the previous assumptions. However, the overall results obtained are similar even though the deviations in the growth rate of Food for Wholesale are relatively small.

Some examples were presented in this chapter of the results of this study in estimating the rates of growth in food requirements during development. The income elasticities of food consumption at different levels of food measurement obtained in the study were used with Ohkawa's equation to estimate the rate of growth in food requirements. The principal finding was that rates of growth in the requirements for Food for Wholesale were shown to rise dramatically from low levels of 1 or 2 percent to 5 percent or more during the early stages of economic development. Subsequently, when levels of per capita income rise to a certain peak, these rates of growth decline due to lower population growth rates and perhaps to lower income elasticities for food. 27/

Chapter XI. -- CONCLUSIONS AND POLICY IMPLICATIONS

Growth in food consumption during economic development is determined by growth in population and income, and by the income elasticity of the demand for food. Estimates of the latter are the most uncertain. During economic development the rate of increase in food consumption is equal to the rate of population growth plus the rate of growth in per capita income times the income elasticity of demand for food.

A set of 6 interlocking measures of the value of food was carefully defined in this study so that the income elasticity of food at each point in the marketing channel could be ascertained. Use of these measures made possible the consistent measurement of the flow of the value of food from farmers' storehouses into consumers' kitchens. As the focus of the study was on the value of total consumption, it was assumed that the usual changes in the mix of foods in the average citizen's market basket occur as development proceeds.

The econometric relations between the income elasticities of the different measures of food were explored to provide a firm framework for the analysis. In the course of reviewing the mathematical relations between the elasticities and in considering the nature of the measure of food, certain restrictive assumptions were found necessary to keep the analysis manageable. These assumptions include no changes in the relative prices of foods or other products, and that the income elasticity of Total Food is the dominant independent elasticity.

27/ Estimates of world food needs using a similar type of analysis were presented recently by Cochrane, Mackie, and Chappell (14).

The setting out of the econometric relations between the income elasticities of the value of food at different levels of measurement demonstrated that in some circumstances the income elasticities of food at different levels of food measurement are the same during economic growth. The more typical situation, however, is for the income elasticities of food at different levels of measurement to be different over long periods of economic growth. These differences in elasticities are the result of the changing structure of national economies associated with economic growth and rising per capita incomes.

Exploration of the econometric framework of the study also demonstrated that constant arc elasticities could be used instead of point elasticities. The use of arc elasticities has the advantage of obviating a choice of mathematical function relating income and food consumption, upon which the calculation of point elasticities depends. An additional advantage of arc elasticities was the ease of presentation and discussion which they permitted. The basic relationships are not changed by the use of arc elasticities, however. This is because the relations between the elasticities are independent of any assumption as to the functional relation between income and food.

With the analytical framework in hand, the analysis focused upon obtaining realistic estimates of the income elasticity of the value of Total Food. A review of a considerable body of data showing the proportion of income spent on food compared with per capita income, demonstrated that with the use of the Engel Curve it is very unlikely that the long-run income elasticity of Total Food is greater than .9 or less than .4 in the per capita income range up to \$1,000. These data also indicate that the usual range for the long-run income elasticity of Total Food is narrower, from .8 to .6 in the income range considered.

Turning to estimates of the income elasticity of Food at Retail, the analytical framework specified that food elasticities at this level are dependent upon changes in the ratio of Food at Retail to Total Food as incomes increase, as well as upon the income elasticity of Total Food. The reason this ratio is important is because as economic growth occurs, a larger and larger proportion of Total Food passes through the Food at Retail channel instead of coming directly to consumers as Home-produced Food. This change is due largely to the increasing urbanization of the labor force.

A search found essentially no data on changes in the ratio of Food at Retail to Total Food as development occurs. Therefore, the changes in this ratio associated with development were estimated by constructing three Retail Food Paths. The Medium Retail Food Path was developed on the basis of the increasing proportion of nonagricultural labor in the total labor force as development progresses. Two additional Retail Food Paths were set out using extreme assumptions. The three paths provide estimates of the rate at which Food at Retail increases as a proportion of Total Food as per capita income grows. These paths thus provide estimates of the elasticity of the ratio of Food at Retail over Total Food. An example of the changes in this proportion is taken from the Medium Retail Food Path. It shows that Food at Retail is 25 percent of Total Food at the \$50 per capita income level. Food at Retail rises on this path to 85 percent of Total Food at the \$1,000 per capita

income level. The three estimates of changes in the ratio of Food at Retail to Total Food obtained in this way were not unreasonable. However, the Retail Food Path followed by a particular nation will, of course, be somewhat different from any of the three paths outlined.

By combining data for the income elasticity of Total Food and data for changes in the proportion of Food at Retail to Total Food, estimates of the income elasticity of the value of Food at Retail were obtained. The major finding was that the income elasticity of Food at Retail appears likely to be from .2 to .6 greater than the income elasticity of Total Food. This is because as development occurs, there is a continuing shift by consumers to the Food at Retail channel away from the Home-produced Food channel. This shift is measured by the increasing ratio of Food at Retail to Total Food. It follows also that if long-run Total Food elasticities are in the neighborhood of .6 to .7, the income elasticity of Food at Retail will be somewhere near 1.0, particularly during the earlier stages of development.

An additional insight gained from the analysis of the income elasticity of Food at Retail was that the elasticity of Food at Retail can decline during development even though the income elasticity of Total Food remains the same. This is possible because shifts to the Food at Retail channel appear to be more gradual at higher income levels. The finding suggests a contributory explanation for the decline at higher incomes in income elasticities of Food at Retail found in some empirical studies.

Income elasticities for Food for Wholesale are needed by developing nations. Estimates of national food requirements at the wharf and farm gate are necessary for sound plans for food production and food imports. The analytical framework of this study showed that in order to obtain estimates of the income elasticity of Food for Wholesale it was necessary to examine changes in the marketing margin. Changes in the marketing margin may have an important influence on the income elasticity of Food for Wholesale. For example, over 5-year periods in the United States, the marketing margin--the ratio of Marketing Costs to Food at Retail--has changed by as much as 5 percentage points. Investigation showed that changes in the marketing margin of this magnitude over a 10-year period associated with an income increase of 20 percent per capita could cause the income elasticity of Food for Wholesale to change by .5 or even more. With the same change in per capita income, a 2 percentage point change in the marketing margin was found to influence the elasticity of Food for Wholesale by .2 and sometimes more. Also, if the income increase was less than 20 percent, the effect on the elasticity of Food for Wholesale of the same changes in the marketing margin would be even greater.

The income elasticities of Food for Wholesale found may be summarized as follows: (1) If there is no change in the marketing margin during development, that is, no change in service components of food, the income elasticity of Food for Wholesale is the same as the income elasticity of Food at Retail. Thus, with no change in the marketing margin the elasticity of Food for Wholesale will probably be somewhere near 1.0. This is a higher elasticity than for Total Food. Only if the income elasticity of Total Food were as low as . with a constant marketing margin, would the elasticity of Food for Wholesale

likely to be much below .7. (2) If there is a change in the marketing margin, the elasticity of Food for Wholesale is modified. In general, a decrease in the marketing margin will increase the income elasticity of Food for Wholesale and vice versa. Changes in the elasticity of Food for Wholesale as large as .2 or .3 are possible with only moderate changes in the marketing margin.

One of the major conclusions that emerges from this study is that the income elasticities of Food at Retail and Food for Wholesale appear likely to remain between .2 to .6 above the income elasticity of Total Food during the process of development in the income ranges considered. The reason these elasticities remain greater than the elasticity of Total Food is due to the shift during development away from Home-produced Food to Food at Retail. This shift to Food at Retail brings out the need for the rapid development of food marketing systems as development, and particularly urbanization, proceeds.

Estimates of the resources needed to meet national agricultural development targets can be better gauged if the production coefficients as well as Supplier Food requirements are known. Supplier Food was defined as net farm food and net fish production plus food imports, or Food for Wholesale minus Home-produced Food. This investigation showed that Supplier Food elasticities appear in general to be about .1 to .2 less than the income elasticity of Total Food. If, for example, the income elasticity of Total Food is .7 and the marketing margin remains constant at 60 percent on the Medium Retail Food Path, the income elasticity of Supplier Food is .56 in the \$50 to \$200 per capita income range. In the \$500 to \$1,000 per capita income range, the income elasticity of Supplier Food drops to .46. Hence, the demand for agricultural resources will generally not grow as rapidly as the value of Total Food per capita. The explanation is that as development occurs a higher and higher proportion of food flows through the Food at Retail and Food for Wholesale channels and Home-produced Food declines proportionately. Due to this change, marketing costs or services gradually increase as a proportion of Total Food, eventually replacing Supplier Food. It should be stressed, however, that if the income elasticity of Total Food remains high at .7 or above, the income elasticity of Supplier Food will probably remain greater than .5 until high per capita income levels are reached.

The income elasticity of Supplier Food is more sensitive to changes in marketing margin at higher per capita income levels and when the marketing margin is high. For example, with a marketing margin initially at 60 percent on the High Retail Food Path, a 5 percent increase in the marketing margin compared with no change in the marketing margin decreases the elasticity of Supplier Food by .05 when income increases from \$50 to \$200. In the \$500 to \$1,000 per capita income range the decrease under the same conditions is .17, more than three times as great (table 18).

A summary of the income elasticities obtained in this investigation may be given with three assumptions about the elasticity of Total Food (table 18). The table shows the range of income elasticities obtained for Food at Retail, Food for Wholesale, and Supplier Food assuming the marketing margin remains constant at 60 percent. Income elasticities of Food at Retail and Food for Wholesale are the same when the marketing margin remains constant.

Table 23.--The range of income elasticities obtained in this study assuming the marketing margin remains constant at 60 percent

Elasticity of Total Food	Per capita income change					
	Food at Retail	Supplier and Food for Wholesale	Food at Retail	Supplier and Food for Wholesale	Food at Retail	Supplier and Food for Wholesale
	:	:	:	:	:	:
	:	:	:	:	:	:
.9	1.69-1.06	.81-.79	1.46-1.10	.73-.70	1.48-.98	.81-.56
.7	1.49-.86	.61-.59	1.26-.90	.53-.50	1.28-.78	.61-.35
.4	1.19-.56	.31-.24	.96-.60	.19-.09	.98-.48	+.14-.05

The ranges in the table are based on the elasticities for the Low and High Retail Food Paths and, thus, should cover most of the probable elasticities. The striking feature of the table is the generally high level of the income elasticities for Food at Retail and Food for Wholesale at all per capita income levels. Supplier Food elasticities remain fairly high except when the income elasticity of Total Food is low.

Some of the implications for rates of growth in national food requirements were worked out. Use of Ohkawa's equation showed that if the income elasticity of food at any level of food measurement is as high as 1.0, while population and per capita income are growing at a rate of 2 percent a year, then national food requirements would increase at an average of about 4 percent per year. If, however, the income elasticity of food were .7, instead of 1.0, the national rate of growth in food consumption requirements would be 3.4 percent per year.

An example of the transition of a low income country from a situation of no growth, where population and income are constant, to a developing economy with higher levels of per capita income was also presented. This example indicates that the rate of growth in Food for Wholesale can be expected to rise as high as 5 percent per year in the period of early development. Later it would decrease to perhaps 3 percent. The important finding is that a dramatic rise occurs in the rate of growth in Food for Wholesale requirements as development gets underway.

Income elasticities obtained for one level of food measurement may also apply to other levels of measurement if it can be demonstrated that there have been insignificant changes in the ratios of the elements involved. This should be of particular interest for those conducting empirical studies with time series data. For example, if an empirical estimate of an income elasticity of .7 for Food at Retail is obtained for a certain period from time series data, this elasticity would also apply to Total Food if it could be

monstrated that the ratio of Food at Retail to Total Food had not changed appreciably during the period. The same elasticity would also apply to Food for Wholesale if no change in the marketing margin had occurred.

Finally, it should be recognized that due to different national cultural and economic environments, somewhat different relations between the income elasticities of food at different levels of measurement should be expected in each country. Thus, the general changes obtained in this study, using international comparisons data, do not apply to any specific country. The elasticities obtained here should not be used for country estimates. To obtain appropriate elasticities for a specific country, estimates of the national parameters for the equations are required.

Perhaps the most important policy implication of the study is that the value of Food at Retail and Food for Wholesale appears to be greater than previous studies have indicated. Income elasticities of food obtained from conventional empirical studies generally range from 1.0 down to .4. Elasticities for Food at Retail obtained in this study concentrate in the range between 1.20 and .80. If there are no changes in the marketing margin these high elasticities also apply to Food for Wholesale, food at the wharf and farm gate level of food measurement.

If the income elasticities found in this study for Food at Retail or for Food for Wholesale prove upon more detailed empirical investigation to be nearly as indicated here, a rule of thumb may be used to estimate changes in food consumption. The rule based on Ohkawa's equation would be: The rate of increase in the value of Food at Retail per year is approximately equal to the sum of the rate of increase in population, plus the rate of increase in per capita income. Thus, for example, if the elasticity of Food at Retail is approximately 1.0 and the rate of per capita income growth were 1 percent per year and population growth rate were 2 percent per year, the total national rate of growth in the value of Food at Retail would be expected to be approximately 3 percent per year.

The model developed in this study focuses attention on the important influence of the shift from Home-produced Food to Food at Retail on the income elasticity of Food at Retail as economic development proceeds. This shift contributes to the high income elasticities for Food at Retail obtained. The shift suggests great strains on the marketing system during economic growth. Thus, development policies placing stress on reducing food Marketing Costs appear particularly appropriate.

Turning the coin over, if a rapid shift to nonagricultural labor is expected in a region, with associated heavy migration of laborers to urban areas, major increases in the demand for Food at Retail should be anticipated. The prospect of these increases imply the necessity of assuring a sufficient expansion in marketing services to prevent unreasonable increases in the prices of Food at Retail.

The results of this study also point to the probability that changes in the marketing margin will have a major influence on the income elasticity of Food for Wholesale (food at the wharf and farm gate). For example, seemingly

small reduction in the marketing margin can increase the income elasticity Food for Wholesale. Inversely, increases in the marketing margin decrease Food for Wholesale income elasticities considerably. From these relations it follows that governments with programs or plans likely to reduce the marketing margin should be prepared for increases in the demand for Food for Wholesale. On the other hand, governments should expect that if there are increases in the marketing margin during development, the rate of growth in Food for Wholesale will slacken.

Important policy implications also emerge with economic growth and are influenced by different rates of per capita income growth on food elasticity. Government operating and planning organizations should be aware that slower rates of per capita income growth will increase the influence of given percentage shifts of food into the Food at Retail channel. Slower rates of growth also will increase the influence of changes in the marketing margin on the income elasticity of Food for Wholesale. On the other hand, faster rates of per capita income growth will tend to minimize the influence of these structural changes on the income elasticity of Food at Retail and Food for Wholesale.

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APPENDIX 1

Table 24.--A Comparison of Measures of Food

Home-produced Food <u>1/</u>	Food for Wholesale <u>1/</u>	Supplier Food <u>1/</u> USDA Supplier Values of Food used by civilians (TFV-5)	Food at Retail <u>1/</u>	USDA Retail Values of Food used by civilian (TFV-9)
Farm value of home-produced food TFV-2	Farm value of domestic food sold to civilians TFV-1	Farm value of domestic food sold to civilians TFV-1		
Import value of imported food TFV-3	Import value of imported food TFV-3	Import value of imported food TFV-3		
Wharf value of domestic fish catch for civilians (TFV-4)	Wharf value of domestic fish catch for civilians (TFV-4)	Wharf value of domestic fish catch for civilians (TFV-4)		
			Retail value of domestic farm foods sold TFV-6	Retail value of domestic farm foods sold TFV-6
				Retail value of home-produced food TFV-7
			Retail value of imported and nonfarm foods TFV-8	Retail value of imported and nonfarm foods TFV-8

Continued --

Table 24.--A Comparison of Measures of Food -- Continued

USDA	:	USDA	:	
Market value of all	:	Expenditures for all	:	Total Food <u>1/</u>
civilian food	:	foods	:	
(TFV-10b) <u>2/</u>	:	(TFV-11b) <u>2/</u>	:	
	:		:	
Market value of home-produced	:		:	Farm value of home-
food TFV-2	:		:	produced food TFV-2
	:		:	
Retail value of domestic	:	Retail value of domestic	:	+ Retail value of domes-
farm foods sold TFV-8	:	farm foods sold TFV-6	:	tic farm foods sold
	:		:	TFV-6
	:		:	
Retail value of imported	:	+ Retail value of imported	:	+ Retail value of im-
nonfarm foods TFV-8	:	ed and nonfarm foods	:	ported and nonfarm foods
	:	TFV-8	:	TFV-8
	:		:	
Eating place markup over	:	+ Eating place markup	:	
retail	:	over retail	:	
	:		:	
Estimated marketing	:	- Estimated marketing	:	
charges saved on food sold	:	charges saved on food	:	
prior to retail level	:	sold prior to retail	:	
	:	level	:	
	:		:	

Terms defined and used in this study.
Including taxes and tips.

Source: Marguerite C. Burk (7), p. 39-42.

Mathematical Relations Between Income Elasticities

I. Variables used (See definitions on p. 8 and in figure 2.)

V_S = Total value of Home-produced Food.

V_P = Total value of Food for Wholesale.

V_M = Total value of Marketing Costs.

$V_A = V_S + V_P + V_M$ = Total value of Total Food.

$V_R = V_P + V_M$ = Total value of Food at Retail.

$V_O = V_S + V_P$ = Total value of Supplier Food.

It then follows that $V_A = V_O + V_M = V_R + V_S$

Additional new variables based on those above are defined as follows:

Let $W_S = \frac{V_S}{V_A}$, $W_P = \frac{V_P}{V_A}$, and $W_M = \frac{V_M}{V_A}$, then $W_S + W_P + W_M = 1$,

Let $W_O = \frac{V_O}{V_A}$, $W_R = \frac{V_R}{V_A}$, then $W_O + W_M = 1$ and $W_R + W_S = 1$,

and then $W_P + W_M = W_R$ and $W_S + W_P = W_O$.

Let $U_P = \frac{V_P}{V_R}$, $U_M = \frac{V_M}{V_R}$, then $U_P + U_M = 1$.

Let $T_P = \frac{V_P}{V_O}$, $T_S = \frac{V_S}{V_O}$, $T_M = \frac{V_M}{V_O}$, then, $T_P + T_S = 1$.

The income elasticity of Home-produced Food is:

$$e_S = \frac{I}{V_S} \frac{d(V_S)}{d(I)} = \frac{d(\log V_S)}{d(\log I)} = \frac{\frac{d(V_R)}{V_R}}{\frac{d(I)}{I}}$$

e_P , e_M , e_A , e_O , and e_R are similarly defined.

The derivation of the relation between the income elasticities of food at different points or levels of measurement. 1/

Since $V_R = V_A \frac{V_R}{V_A} = V_A W_R$, the derivative of V_R with respect to income (I) is:

$$\frac{d(V_R)}{d I} = \frac{d(V_A W_R)}{d I} = V_A \frac{d(W_R)}{d I} + W_R \frac{d(V_A)}{d I}$$

by multiplying both sides of the equation by $\frac{I}{V_R} = \frac{I}{V_A W_R}$ the elasticities are obtained:

$$\frac{I}{V_R} \frac{d(V_R)}{d I} = \frac{I}{V_A W_R} \frac{d(V_A W_R)}{d I} = \frac{I}{W_R} \frac{d(W_R)}{d I} + \frac{I}{V_A} \frac{d(V_A)}{d I}, \text{ or}$$

$$e_R = e_A + \frac{I}{W_R} \frac{d(W_R)}{d I} = e_A + \frac{d(\text{Log } W_R)}{d(\text{Log } I)}. \text{ Since } \frac{I}{W_R} \frac{d(W_R)}{d I} \text{ is}$$

the elasticity of the proportion, W_R , the symbol e_{W_R} may be used for it.

$$\text{Then } e_R = e_A + e_{W_R}.$$

Similarly, the elasticities of the other proportions are written as e_{W_S} , e_{W_O} , e_{W_M} , e_{W_P} , e_{U_P} , e_{U_M} , e_{T_P} , e_{T_S} , and e_{T_M} . For the purposes of this analysis, it is convenient not to assume any specific functional relation between income and the value of food. Instead, as a first approximation, arc elasticities between specified points are calculated. For this purpose the constant arc elasticities were calculated by using the equation for the slope in Logs. Thus, as

$$m = \frac{\text{Log } V_{R2} - \text{Log } V_{R1}}{\text{Log } I_2 - \text{Log } I_1} \text{ then } e_R = \frac{\Delta \text{Log } V_R}{\Delta \text{Log } I}.$$

$$\text{Similarly } e_{W_R} = \frac{\Delta \text{Log } W_R}{\Delta \text{Log } I}. \text{ This equation implies that the relation}$$

between V_R and I for specified limits can be represented by the function:

1/ Equations given by Wold (56, p.100) and by Daly (18, p. 78) and discussions with Forrest Walters and Shlomo Reutlinger suggested the approaches used in this appendix.

$\log V_R = \log K_R + e_R \log I$, which, of course, has a constant elasticity.

Under this assumption e_R is measured exactly by $\frac{\Delta \log V_R}{\Delta \log I}$. For quick approximations over small changes in income the arc elasticity may be estimated by the equation:

$$e_R = \frac{\frac{V_{R2} - V_{R1}}{V_{R2} + V_{R1}}}{\frac{I_2 - I_1}{I_2 + I_1}}$$

For small changes in income, this estimate is approximately equal to the exact elasticity relation.

III. Relations between two arc elasticities.

In ways similar to the preceding derivation, the equations given below were obtained to relate the elasticities. These equations assume a function with constant elasticities between the specified points.

Food Variables Included

A. The relations between the elasticities of Food at Retail and Total Food are: (See derivation above)

$$(A1) \quad e_R = e_A + \frac{\Delta \log W}{\Delta \log I}, \quad \text{or} \quad e_R = e_A + e_{WR}. \quad V_R, V_A$$

This may be expanded as follows:

$$\begin{aligned} e_R &= e_A + \frac{\Delta \log \frac{V_R}{V_A}}{\Delta \log I} \\ &= e_A + \frac{\Delta \log V_R - \Delta \log V_A}{\Delta \log I} \end{aligned}$$

Then using the definitions $V_R = \frac{V_M}{U_M}$ and $V_A = \frac{V_M}{W_M}$

Food Variables
Included

$$e_R = e_A + \frac{\Delta \log \left(\frac{V_M}{U_M} \right) - \Delta \log \left(\frac{V_M}{W_M} \right)}{\Delta \log I}$$

$$= e_A + \frac{\Delta \log V_M - \Delta \log U_M - \Delta \log V_M + \Delta \log W_M}{\Delta \log I}$$

Thus,

$$(A2) \quad e_R = e_A + \frac{\Delta \log W_M}{\Delta \log I} - \frac{\Delta \log U_M}{\Delta \log I} \quad V_R, V_A, V_M$$

In a similar way it was found that

$$(A3) \quad e_R = e_A + \frac{\Delta \log W_P}{\Delta \log I} - \frac{\Delta \log U_P}{\Delta \log I} \quad V_R, V_A, V_P$$

The equation may be further expanded to:

$$(A4) \quad e_R = e_A + \frac{\Delta \log W_O}{\Delta \log I} + \frac{\Delta \log T_P}{\Delta \log I} - \frac{\Delta \log U_P}{\Delta \log I} \quad V_R, V_A, V_O, V_P$$

B. The relations between the elasticities of Food at Retail

and Food for Wholesale and Food at Retail and Marketing Costs are obtained in a similar way. They are:

$$(A5) \quad e_P = e_R + \frac{\Delta \log U_P}{\Delta \log I} \quad \text{or } e_P = e_R + e_{U_P}, \quad \text{or} \quad V_R, V_P$$

$$= e_R + \frac{\Delta \log (1 - U_M)}{\Delta \log I}$$

$$(A6) \quad \text{and } e_M = e_R + \frac{\Delta \log U_M}{\Delta \log I} \quad V_R, V_M$$

C. The relation of the elasticities of Food for Wholesale and Total Food are:

$$(A7) \quad e_P = e_A + \frac{\Delta \text{ Log } W_P}{\Delta \text{ Log } I} \quad \text{which may be expanded to,} \quad V_P, V_A$$

$$(A8) \quad e_P = e_A + \frac{\Delta \text{ Log } W_R}{\Delta \text{ Log } I} + \frac{\Delta \text{ Log } U_P}{\Delta \text{ Log } I} = e_A + \frac{\Delta \text{ Log } W_R}{\Delta \text{ Log } I} +$$

$$\frac{\Delta \text{ Log } (1 - U_M)}{\Delta \text{ Log } I}, \text{ or } e_P = e_A + e_{W_R} + e_{U_P} \quad V_P, V_A, V_O$$

$$(A9) \quad \text{or to } e_P = e_A + \frac{\Delta \text{ Log } W_O}{\Delta \text{ Log } I} + \frac{\Delta \text{ Log } T_P}{\Delta \text{ Log } I} \quad V_P, V_A, V_O$$

D. Similarly the elasticities of Supplier Food and Total Food are related as follows:

$$(A10) \quad e_O = e_A + \frac{\Delta \text{ Log } W_O}{\Delta \text{ Log } I} \quad \text{which may be expanded to,} \quad V_O, V_A$$

$$(A11) \quad e_O = e_A + \frac{\Delta \text{ Log } W_P}{\Delta \text{ Log } I} - \frac{\Delta \text{ Log } T_P}{\Delta \text{ Log } I} \quad V_O, V_A, V_P$$

$$(A12) \quad \text{or to } e_O = e_A + \frac{\Delta \text{ Log } W_S}{\Delta \text{ Log } I} - \frac{\Delta \text{ Log } T_S}{\Delta \text{ Log } I} \quad V_O, V_A, V_S$$

which may further be expanded to,

$$(A13) \quad e_O = e_A + \frac{\Delta \text{ Log } W_R}{\Delta \text{ Log } I} + \frac{\Delta \text{ Log } U_P}{\Delta \text{ Log } I} - \frac{\Delta \text{ Log } T_P}{\Delta \text{ Log } I} \quad V_O, V_A, V_P, V_R$$

$$\text{or} \quad e_O = e_A + e_{W_R} + e_{U_P} - e_{T_P}$$

E. Similarly the elasticities of Total Food and Home-produced

Food and Total Food and Marketing Costs are related in this way:

$$(A14) \quad e_S = e_A + \frac{\Delta \text{ Log } W_S}{\Delta \text{ Log } I} \quad V_A, V_S$$

$$(A15) \quad e_M = e_A + \frac{\Delta \text{ Log } W_M}{\Delta \text{ Log } I} \quad V_A, V_M$$

F. Similarly, the relation between the elasticities of Subsistence Food and Food for Wholesale Food and Supplier Food are:

$$(A16) \quad e_A = e_O + \frac{\Delta \text{ Log } T_S}{\Delta \text{ Log } I} \quad V_O, V_S$$

$$(A17) \quad e_P = e_O + \frac{\Delta \text{ Log } T_P}{\Delta \text{ Log } I} \quad V_O, V_P$$

APPENDIX 3

Table 25.--International comparisons of food expenditure and national consumption expenditure, 35 countries, 65 observations, 1953 dollars 1/

Country	National consumption expenditure	The ratio of food expenditure to private consumption expenditure	Food expenditure col. 1 x col. 2
	Dollars	Percent	Dollars
<u>Australia</u>			
1953	720	26	187.20
1960	926	25	232
<u>Austria</u>			
1953	291	39	113
1960	422 ('59)	35 ('59)	148
<u>Belgium</u>			
1953	711	30	213
1960	816	28	228
<u>British Guiana</u>			
1953	165	40	66
1960	---	--	---
<u>Canada</u>			
1953	1,069	24	256
1960	1,243	23	286
<u>Ceylon</u>			
1953	93	54	50
1960	91	52	47
<u>China (Taiwan)</u>			
1953	102	61-9=52 <u>2/</u>	53
1960	88	57-9=48 <u>2/</u>	42
<u>Denmark</u>			
1953	598	28	167
1960	777	25	194
<u>Dominican Rep.</u>			
1953	135	50-9=41 <u>2/</u>	55
1960	142 ('58)	52-9=43 ('58) <u>2/</u>	61
<u>Ecuador</u>			
1953	109	50	54
1960	123	44	54

Table 25.--International comparisons of food expenditure and national consumption expenditure, 35 countries, 65 observations,
1953 dollars 1/ -Continued

Country	National consumption expenditure	The ratio of food expenditure to private consumption expenditure	Food expenditure col. 1 x col. 2
	<u>Dollars</u>	<u>Percent</u>	<u>Dollars</u>
<u>of Malaya</u>			
53	---	--	---
60	159 ('59)	47 ('59)	75
<u>and</u>			
53	484	40	194
60	533	38	202
<u>ce</u>			
53	681	35	238
60	762	31	236
<u>a</u>			
53	---	--	---
60	---	--	---
<u>ce</u>			
53	169	49	83
60	251 ('59)	46 ('59)	115
<u>uras</u>			
53	142	49	70
60	142 ('58)	43 ('58)	61
<u>and</u>			
53	364	39	142
60	408	38	155
<u>y</u>			
53	282	47	132
60	365	45	164
<u>ica</u>			
53	183	44	80
60	293	35	102
<u>n</u>			
53	135	56-9=47 <u>2/</u>	63
60	204	46-9=37 <u>2/</u>	75

Table 25.--International comparisons of food expenditure and national consumption expenditure, 35 countries, 65 observations, 1953 dollars 1/ -Continued

Country	National consumption expenditure	The ratio of food expenditure to private consumption expenditure	Food expenditure col. 1 x col. 2
	Dollars	Percent	Dollars
<u>Jordan</u>			
1953	---	---	---
1960	121 ('59)	51-9=42 ('59) <u>2/</u>	51
<u>Korea Republic</u>			
1953	88	50	44
1960	95	50	48
<u>Luxembourg</u>			
1953	640	34	218
1960	776 ('59)	35 ('59)	272
<u>Malta</u>			
1953	222 ('54)	43 ('54)	95
1960	271	38	103
<u>Netherlands</u>			
1953	367	35	128
1960	501	31	155
<u>Nigeria</u>			
1953	54	72	39
1960	65 ('57)	70 ('57)	46
<u>Norway</u>			
1953	537	30	161
1960	674	29	195
<u>Panama</u>			
1953	275	38	104
1960	293	38 ('59)	111
<u>Puerto Rico</u>			
1953	412	34	140
1960	562	29	163
<u>Rhodesia and Nyasaland</u>			
1953	92 ('54)	43 ('54)	40
1960	111	40	44

Table 25.--International comparisons of food expenditure and national consumption expenditure, 35 countries, 65 observations, 1953 dollars 1/ -Continued

Country	National consumption expenditure	The ratio of food expenditure to private consumption expenditure	Food expenditure col. 1 x col. 2
	Dollars	Percent	Dollars
Denmark	674	31	209
53			
60	872	27	235
Land			
53	---	--	---
60	78 ('59)	47 ('59)	37
Trinidad & Tobago			
53	---	--	---
60	332 ('59)	38 ('59)	126
United Kingdom			
53	625	31	194
60	815	30	244
United States			
53	1,432	25	358
60	1,651	22	363
Yugoslavia			
53	117	54	63
60	99	47	46

Currencies converted at official exchange rates on the basis of work by the (37).

Where data included beverages, the average of 9 percent of national consumption expenditure used for beverages in the other countries was subtracted to obtain a food only estimate.

Source: United Nations Statistical Yearbooks for 1959, table 169 and for 1960, table 166.

APPENDIX 4

Table 26.--The proportion of the active population engaged in
agricultural occupations compared with
per capita income in 70 countries

Per capita income group	Country	Average : national : income : per capita : 1953-55 : 1/	Active population : in agricultural : occupations : Averages : Simple : average for : each group : 1945-60 2/	Active : populatio : in non- : agricultur : occupation : average
		Dollars	Percent	
\$950 and above	United States	1,916	12	
	Canada	1,311	12	
	Sweden	1,047	20	15
	Switzerland	1,064	16	85
	New Zealand	1,062	16	
\$949 to \$650	Australia	947	13	
	Luxembourg	889	26	
	United Kingdom	795	5	
	Belgium	790	12	
	France	804	26	24
	Denmark	746	23	76
	Norway	743	26	
	Iceland	677	40	
	Finland	710	46	
\$649 to \$350	Venezuela	640	41	
	West Germany	588	15	
	Israel	480	3/17	
	Netherlands	539	19	
	Czechoslovakia	468	38	29
	Austria	396	32	71
	Puerto Rico	432	25	
	Ireland	416	40	
	Hungary	390	38	
\$349 to \$250	Poland	340	57	
	Italy	337	30	
	Trinidad	292	25	
	U. South Africa	295	33	
	Cyprus	318	38	39
	Panama	297	50	61
	Argentina	317	25	
	Cuba	311	42	
	Costa Rica	273	55	

Table 26.--The proportion of the active population engaged in agricultural occupations compared with per capita income in 70 countries -Continued

Per capita income group	Country	Average national income per capita 1953-55 <u>1/</u>	Active population in agricultural occupations		Average for 1945-60 <u>2/</u>	Simple average for each group	Active population in non-agricultural occupations average
		Dollars	-----Percent-----				
\$249 to \$150	: Chile	214	30				
	: Jamaica	205	49				
	: Japan	191	40				
	: Greece	210	48				
	: East Germany	175	15				
	: Mexico	191	58				
	: Brazil	177	58				
	: Spain	229	49				
	: Dominican Republic	196	56	54		64	
	: Portugal	170	48				
	: Colombia	230	54				
	: British Guiana	209	46				
	: Algeria	184	75				
	: El Salvador	187	63				
	: Turkey	241	77				
	: Honduras	160	84				
	: Morocco	161	71				
\$149 to \$75	: Yugoslavia	143	67				
	: Indonesia	107	66				
	: Bulgaria	128	64				
	: Philippines	142	59				
	: Rhodesia and Nyasaland	126	34				
	: Tunisia	141	68				
	: Ecuador	136	53				
	: Guatemala	135	68	63		37	
	: Egypt	116	64				
	: Peru	105	62 (1930-44)				
	: Korea	101	80				
	: Ceylon	116	53				
	: China (Taiwan)	103	50				
	: Paraguay	92	52				
	: Haiti	100	83				
	: Thailand	105	88				
\$74 and below	: Congo (Ex. Belgium)	73	85				
	: Nigeria	70	74				
	: India	56	71	73		27	
	: Pakistan	66	65				
	: Burma	43	68 (1930-44)				

1/ Arthur B. Mackie (37).

2/ FAO: Production Yearbook, 1961, pp. 19-21.

3/ Jewish population.

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